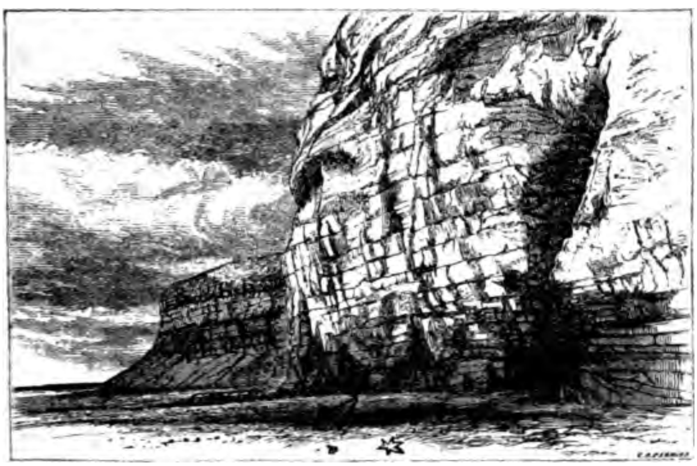
THE YORKSHIRE LIAS.

BY

RALPH TATE, F.G.S., A.L.S.,

AND

J. F. BLAKE, M.A., F.G.S.



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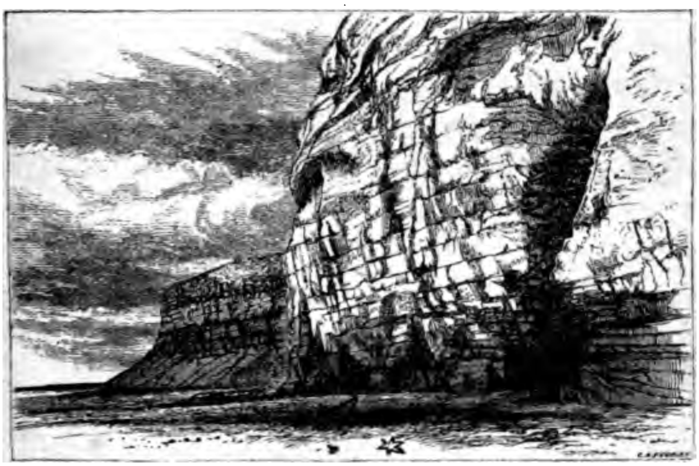

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PREFACE.

It is with great satisfaction that we at last present the work that has occupied our attention for some years. The delay in its publication, after having been so long promised, has been beyond our control; and we have finally been obliged to undertake it at our own risk. The work appeals to a limited number of the public, viz. geologists and those interested in the Iron Industry of Cleveland; for such, therefore, it has been written; and we have done our best, by being as accurate as we know how to be in our statements, to make it worthy of their attention. It contains much detail, all of which cannot be interesting to every one; but if some portion satisfies the requirements of each, he will, it is hoped, excuse the rest being written for some one else. We cannot hope to have escaped error; and in the case of the names of fossils, our second Part is sometimes inconsistent with the first: in such instances the former is to be taken as a correction on the latter. With respect to the map, we may say that no details have been omitted which would appear on the 1-inch scale, from which it is an accurate reduction; and if reenlarged it will give the proper

lines (according to our judgment) on the original scale. Where the lines are uniformly curved or straight, as, for example, between Easingwold and Barton, it may be taken that we possess no very accurate information, owing to the covering of the underlying rocks, and the absence of workings; otherwise the lines are well established. The assistance we have received is acknowledged in the place where we have used it; but we think we ought especially to acknowledge the kindness of Mr. Simpson, the Curator of Whitby Museum, who has permitted us to examine his types, though we have often thereby come to a different opinion as to their interpretation.

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At the end. General Sections and Plan of Robin Hood's Bay, on two folding plates.

PART I.

GEOLOGY.

THE

YORKSHIRE LIAS.

CHAPTER I.

GENERAL RANGE OF LIASSIC STRATA ON THE CONTINENT AND BRITISH ISLES.

BENEATH the Oolitic rocks which form the hills of the midland counties, and resting upon the red marls and sandstones which spread out in the great central plain of England, is a series of blue clays and shales of considerable thickness, interstratified with beds of sandstone, ironstone, and limestone. To this series the name of Lias has been assigned, a local term supposed to be a corruption of "layers," in allusion to the evenness of its bedding in many localities. From the number of its valuable contents—ironstone, jet, alum shale, cement, and limestones—it is of considerable industrial importance, while the quantity and variety of its fossils have always attracted to it a more than ordinary share of the attention of geologists, especially as it presents to us in England the first full series of organic remains of the Secondary period. Beds of this age and character, though not so continuous over large areas as many other formations, are widely spread throughout Europe, and are found also in India. Their most easterly known European occurrence is in the Crimea (see Baily, Q. J. Geol. Soc. vol. xiv. 1858); but throughout the rest of Russia they appear to be wanting. The next appearance coming westwards is in Hungary, where most of the subdivisions occur in the neighbourhood of Funfkirchen, as described by Peters, and the lower part in the north-western portion. Near Vienna we have the eastern limit of a vast range of Liassic rocks, which spread westward without intermission as far as the Vorarlberg, and form the northern slopes of the Austrian, Bavarian, and Rhætian Alps; and although no complete treatise on the Lias of this district has been written, several important memoirs have thrown light upon various parts of it. Of these we may mention:— Hauer's 'Cephalopoda of the N.E. Alps,' and other works by the same author; Gümbel's 'Bayerische Alpengebiete,' with a large geological map of Bavaria; Suess and Dittmar on the Hallstadt

fossils; Stolickza on those of Hierlatz; Schafhäutl's 'Süd-Bayerns Lethæa Geognostica,' and many other smaller works.

Corresponding to this area and bounding on the N.W. the basin of which it is the southern limit, there is another long strip of Lias, nearly continuous in a N.E. direction from Bâle to Coburg, and forming part of the Swabian alps. In this district it has had many historians, the earliest memoir dating many years back. The chief of them is undoubtedly Quenstedt, the materials for whose work, 'Der Jura,' are taken from this area. Another important but antiquated work on this range is Zieten's 'Petrefacten Würtembergs,' not to mention older works. Being the only area in S. Germany in which Liassic beds occur, all the German geologists who have given their attention to rocks of Secondary age have naturally contributed to our knowledge of the formation; so that of all continental localities this is known the best, both as to its stratigraphy and its organic remains. It is here that many of the subdivisions have been first established, and the majority of the fossils have been recognized and named. To give a list of the writings which have enriched the literature of the formation would be to transcribe the names of the works of the greater number of German geologists; yet we cannot perhaps pass over unmentioned that of Oppel, who was one of the foremost. There is one outlying area, now included in the German empire, but formerly belonging to the kingdom of Hanover, to the north of the main mass, to which little attention had been paid till within the last few years, the chief works being Seebach's 'Hanoversche Jura,' Bronn's 'Untere Jura im N.W.-Deutschland,' and papers by Schlonbach, Emerson, and Bornemann. The general work also of Römer contains some account of it.

Coming to France, we find corresponding to the main Swabian range one nearly parallel, but with a more northerly direction, sweeping round from the N.W. side of the Jura mountains by Nancy to Luxembourg. Here, too, the Lias has been well described, especially as to its lower part, chiefly by Terquem in the neighbourhood of Metz and Hettange, and by Chapuis and Dewalque nearer to Luxembourg. This range is really the north-easterly termination of a longer one that stretches right across France to the Bay of Biscay; but on this part of its course comparatively little has been written, excepting of its eastern end, on which we have the admirable monograph of Martin on the Infralias of the Côte d'Or. Branching off from this and forming the southern boundary of the central plateau of France is another range, carrying the Lias in scattered patches in a semicircular course to the Rhone. The more eastern portion of this has been recently illustrated in a series of most valuable monographs by Dumortier, lately completed, and now forming one of the most important of the modern additions to our knowledge of the palæontology of this period. Between this, again, and the German area are some scattered patches described by Favre in his 'Terrain Liassique de Savoie,' also the Swiss Lias whose organic remains have been illustrated by Renevier and Ooster; while to the west the region of the Aveyronnais is well illustrated by Reynes,

whose works are specially valuable, as he recognizes the division into zones, and shows how far they hold in his district. Over all these ranges in S. Germany and France, as well as in England, it has a general historian in Oppel, though over so wide an area it is impossible to expect much of details.

Outlying from these ranges to the south, Italy supplies an important area in the Lombardian Alps, where the lower beds chiefly have been illustrated by Stoppani, in his 'Paléontologie Lombarde,' and by Catullo,—and another in the Vaudois Alps, described by Renevier; while, still further south, beds of this age around the Gulf of Spezzia have been described by Capellini and others, and in Spain and Minorca by Haime and De Verneuil. Separated from all these areas by space, but intimately connected with each by organic remains, is another tract, which commences in Normandy and (crossing in all probability the English Channel) reaches Britain on the coast of Dorset, and has a continuous range till it ends in Yorkshire. We are well acquainted with the Norman area by the labours of the two Deslongschamps.

The Lias enters England grandly, occurring first in the magnificent cliffs of Lyme Regis, surpassing even those of the coast of Yorkshire for the variety and novelty of their organic remains. This, however, would appear to be the northern extremity of a basin which is now nearly washed away, as it soon loses its character inland, and in the neighbourhood of Ilminster, scarcely twenty miles to the north, it is replaced by rubbly redeposited beds, formed of the broken pieces of Liassic rocks that have disappeared, which, though in the highest degree interesting and with a fauna of marvellous beauty, yet show neither the stratigraphical completeness nor the variety of fossils of Lyme Regis. The Ilminster beds have been indefatigably explored by Charles Moore, Esq., who has obtained from them the most complete invertebrate fauna yet known in this age, as well as remarkable fish- and reptile-remains. Though each fossil from Lyme Regis has always attracted its share of attention, yet a general account of the formation in that locality is much needed, the only modern memoir being that of Mr. Day, which was published in 1863, in the Quart. Journ. of the Geol. Soc., and contains complete accounts of the sections of the middle and upper beds observable on the coast. Mr. Moore's chief contributions are contained in a paper on the Middle and Upper Lias of the South-west of England, published in the Somersetshire Archæol. and Nat. Hist. Soc. Proceedings for 1865-6, and another "On Abnormal Conditions of Secondary Deposits," in the Quart. Journ. Geol. Soc. for 1867. In these are contained our most recent information with regard to the southern area.

Coming northwards to Bath, we find only the Lower Lias and part of the Middle Lias represented; but these spread out to the north of Bristol, and we have the whole series present in the Cheltenham district. Various writers have contributed to our knowledge of the Bristol district; but no very complete account has appeared. The Lias about Cheltenham has been well described by Dr. Wright,

in a communication to the Geological Society in 1860, which, however, is not confined to that neighbourhood, and which illustrates Oppel's division of the series into Ammonite zones. The majority of these zones we have adopted in the present work. He has also published a controversial paper on the upper limit of the Lias, which will be discussed in the sequel. An older work on the same area is Buckman's 'Geology of Cheltenham,' 1845. The most recent contribution to one part of the series is a paper by one of us in the Quart. Journ. G. S. for 1870, "On the Junction beds of the Lower and Middle Lias." From the area of Bristol and Cheltenham there runs a westward spur of the lowest beds of Lias—reaching south of the Severn to Watchet, but to the north stretching beyond Bridgend in Glamorganshire. The Quarterly Journal also contains papers on this region by Dawkins, Tawney, Moore, &c. North-easterly from Cheltenham the Lias takes a continuous course through the midland counties Warwickshire, Leicestershire, Nottingham, and Lincolnshire. Throughout this range it has met with comparatively few observers, papers by Beesley, Brodie, &c. on Oxfordshire and Warwickshire being the only recent ones. Lincolnshire especially, except in a limited locality (Marton), is almost entirely unknown, and promises to be an interesting field from the few fossils gathered there. Mr. Cross, however, has recently described the Liassic beds at Frodingham (Quart. Journ. Geol. Soc. vol. xxxi. 1875, p. 115). From Lincolnshire the Lias crosses into Yorkshire, where its range and character become the subject of the present work. North of this point it is met with but in scattered patches—in Shropshire, Cumberland, the eastern coast and western isles of Scotland, and the north of Ireland, the last three localities being severally described by Portlock, Geikie, Judd, Bryce, and Tate. It will be noticed that with respect to the English Lias our information consists almost entirely of memoirs relating to various portions of it in particular districts, and that no complete account of the Liassic beds as exhibited in any locality has yet appeared. How far the Yorkshire series may be considered typical for the rest of England is a question which may better be considered at the end than at the beginning of this work; but we may at once state that the whole series is at least so far fully developed as to enable us to illustrate the whole series from its oldest to its newest stratum.

CHAPTER II.

LITERATURE OF THE YORKSHIRE LIAS.

I. *Chronological History of the principal Geological Memoirs.*

In giving an account of what has been already written on our subject, we may leave out of consideration those notices which only occur casually in general works, and those in which particular fossils from these strata are described; the latter will be dealt with in the Palæontological section.

1818. The first notice is that of the Rev. G. Young, in his 'History of Whitby,' in which he describes the alum strata of the vicinity of that town; but the importance of this geological contribution is overshadowed by the same author publishing, four years after, a full account of the geology of the whole Yorkshire coast.

1821. Smith published a geological map of Yorkshire, but by an error threw no light on the Lias.

1822. In this year appeared Young and Bird's 'Geological Survey of the Yorkshire Coast.' In this the whole series receives the name of the alum shale, though it is said to correspond to the Lias of the southern counties. A very fair description of the various members of the series, as seen on the coast section, is given, the Upper Lias receiving the name of main bed of alum shale; the ironstones of the Middle Lias are described, but only as thin bands as they appear on the shore, under the name of the Kettleness beds; the beds below these receive the title Staithes beds; and the Lower Lias appears as the lowest alum shale. The descriptions of sections seen are accurate and useful, and the information conveyed is considerable. The same authors attempted a map of the interior; and though they profess to have visited every accessible section, the resulting map is entirely an imaginary one and of no value whatever. They also gave an account of the fossil remains; but their figures are rough and scarcely recognizable, so that the names they bestowed can only in a few instances be retained.

1826. Prof. Sedgwick published a paper in the 'Annals of Philosophy' "On the Classification of the Strata which appear on the Yorkshire Coast," and, following the description of the strata as given by Young and Bird, finds it necessary still to prove that the alum shale series (as the whole is still called) is equivalent to the Lias of other districts.

1826. "An account of the Strata north of the Humber near Cave," by the Rev. W. Vernon (afterwards Harcourt), in the 'Annals of Philosophy.' In this paper the range of the Lias at its most

southerly appearance, with that of other strata, is traced with considerable accuracy on a small geological map, which has not yet been improved. He also gives a few valuable notes, showing that he had seen what we now know represents the Cleveland ironstone, and records its existence at Everthorpe, where it can no longer be seen.

1828. In this year Young and Bird published the second edition of the 'Geological Survey,' in which they add nothing to the stratigraphical information, but describe several new fossils unnoticed in their previous edition.

1829. Phillips's 'Illustrations of the Geology of Yorkshire,' part 1, "The Yorkshire Coast." This well-known work, embracing all the Secondary formations of the county, has been, up to this time, the chief authority on the Liassic strata; in it is given a description of them as displayed upon the coast, with sections at various places, and scattered notices of their inland occurrence. In this work the Lias is first divided into the Upper, Middle, and Lower, and full lists of fossils given from each of these divisions. Though, however, the main outlines of the present classification were thus laid down, the additional materials in the shape of new fossils were not so large, as only twenty-seven previously unknown are figured, and unfortunately not described, which leaves their identification in some cases doubtful; of the remainder recorded, forty-seven are adopted from Sowerby's 'Mineral Conchology,' twenty-five from Young and Bird, and six from other sources.

1835 saw the second edition of this work, which, as nothing was added in the interval, may be regarded as a reprint of the first edition.

1836. In vol. v. of the second series of the 'Geological Transactions' were published two papers:—

The first by Louis Hunton, "Accompanying remarks to a section of the Upper Lias and Marlstone of Yorkshire, showing the limited vertical range of the species of Ammonites and other Testacea, with their value as geological tests." This section was that exposed in the alum works at Boulby and the Middle Lias beds exposed in the cliff beneath them, termed by him the "Ironstone" and "Marlstone" series. He here describes the strata in order, and states what fossils are found in each, and the range of them from bed to bed. The paper contains very valuable information upon a limited portion of the series, and is the first attempt to do what we have undertaken in the present work, namely to localize the fossils in their various horizons.

In the second paper by W. C. Williamson, "On the distribution of fossil remains on the Yorkshire coast," the same work is attempted for the whole of the Lias, and the more easily discovered facts are accurately laid down, aud the series of beds divided into (1) the Lower Lias, (2) the Marlstone, (3) the Upper Lias or alum shale—drawing the lines at the same horizons as had been done by Phillips in 1829–35.

Seventeen years now elapsed before any further contribution was made to our knowledge; but the next was an important one. In

Young and Bird's work the accompanying geological map was, as far as the Lias is concerned, purely imaginary, and threw no light whatever on its range; in Phillips's work the map, though small (only the size of a quarto page), was more accurate, and gave the general features of the range of the Lias with tolerable correctness; but in

1853 Phillips published a large geological map of Yorkshire, which has been, since its appearance, the only guide relied on by all map-makers. In it the roads and other such landmarks are omitted, and its value is deteriorated by the bad topography; no dislocations of strata are inserted; and the Lias is mapped as a whole, with only partial indications of the presence of Middle Lias beds. It is thus by no means an exhaustive map; but it is in the highest degree suggestive. It has been the basis of our own survey, as it has told us where to look for Lias, and where, if we look, we shall find none though we might expect it; and though we are able to correct many details, especially in the northern part, yet on the whole we cannot but admire its near approach to fact.

1856. Dr. Albert Oppel, who in his thirty-two short years of life made himself a name and contributed a vast amount of knowledge to geological science, had been led, from his study of the German Lias, to divide the whole into parts, which he called zones, and which were characterized by particular species of *Ammonites*, and generally by a special fauna (which zones have been found most useful, and we retain them in the present work), in this year published his 'Juraformation Englands, Frankreichs und süd-westlichen Deutschlands.' In this he gave a general view of the various zones; but having, in order to render his work complete, visited Yorkshire, he gives incidentally throughout his first part, which relates to the Lias, various notices which have the effect of comparing the Yorkshire Lias with that of other parts, showing the existence of these zones in our area, and, in the palæontological part, noticing the fossils he found in the various zones in this country. His work, though a general one, thus laid the basis of the foundation on which we now build; and ours is the complete (as far as we can make it) carrying out of the ideas then promulgated, and shown to hold good for Yorkshire.

1857. Morley, John, "Cleveland Ironstone." 'Transactions of North of England Institute of Mining Engineers, Newcastle,' vol. v. pp. 165–219. In this paper are recorded the most material facts connected with the development of the ironstone trade of the northern part of the Cleveland district. The chief topics are:—the ironworks in the northern counties prior to the discovery of the ironstone, and to the application thereof in the north part of Cleveland; the history of the discovery of ironstone; a sketch of the principal mines opened out since 1850, accompanied by tabular sections of the ironstone series at each place, and including notices of the top seam; analyses of the stone of the main and top seams; concluding with an account of the blast-furnaces erected since 1846, and a few facts connected with the possible extension of the Coal-measures of Durham into North Yorkshire.

1858. Phillips contributed a paper to the Geological Society, entitled "Comparative Sections in the Oolitic Ironstone Series of Yorkshire." The greater part of this is occupied with the Lower Oolites, their character and range, incidentally throwing light on the upper line of junction of the Lias. He also gives three sections of the latter, at Eston, Grosmont, and Feliskirk—the last the most important, as it was obtained by a boring of which this is the only reliable record.

1860. The volume of the Geological Society's Journal for this year contains two papers by Dr. Wright, of Cheltenham, both of which have partial reference to the Lias of Yorkshire. The first is "On the Subdivisions of the Inferior Oolite in the South of England compared with the equivalent beds of that formation on the Yorkshire coast." In 1856 Dr. Wright described the sandy beds, containing a large number of Ammonites, which in the south of England overlie the true Lias clays which had been formerly classed with the Inferior Oolite; and these he proposed to incorporate with the Lias under the name of Upper Lias Sands, on the ground of the identity of their Cephalopoda with species reckoned Liassic by continental authors. In this paper of 1856 he makes no allusion to Yorkshire; but in the paper now under review he describes certain beds at Blea Wyke in Yorkshire, and correlates them with those he had thus called Liassic. We shall, in the sequel, give our reasons for considering them to belong to the Inferior Oolite, so that we do not regard them as really belonging to our subject; but as they are held to be Liassic by many geologists on the authority of Dr. Wright, it becomes our duty to discuss them. The second paper is "On the zone of *Avicula contorta* and the Lower Lias of the south of England." This is the first attempt to apply the system of Ammonite zones, originated by Dr. Oppel, to the Lias beds of England by any native geologist; and though it has reference chiefly to the south of England, with which Dr. Wright was most familiar, yet it contains scattered notices of the zones, as far as the Lower Lias is concerned, as they are seen on the coast at Robin Hood's Bay. And here we must note that the line of demarkation between the Lower and Middle Lias has been shifted since the time of Phillips, or, rather, that two different lines are drawn by two sets of geologists: the one set, including the Geological Survey, Phillips, and Simpson, draw the line at the base of the limestones and sandstones of the Middle Lias, which is thus a lithological line; the other set, including Dr. Oppel, Dr. Wright, and ourselves, draw it further down, in the middle of the series of clays, where no very marked lithological change takes place, but there is a break in the continuity of the fauna, as clearly shown by one of us in a paper in the Geological Society's Journal for 1870; so that this is a palæontological line.

1861. Jos. Bewick, 'A Geological Treatise on the district of Cleveland, in North Yorkshire, its Ferruginous Deposits, Lias, and Oolites.' This work covered to a great extent the ground which we would now occupy. Like ourselves, he attempted to give the range of the Lias beds by means of a map, with especial reference

to the ironstone strata. He described the position of the various subdivisions, and gave accurate accounts of the most important sections. It might seem therefore that he had done all that was needful for the Yorkshire Lias; but an examination of his work shows that it is not so. In the first place, he was not a geologist, but a mining engineer, and he examined the country solely with mining objects in view, and thus failed to see it with that comprehensiveness that is needful; and on its palæontology he threw no light at all; and the whole work was limited to the Cleveland district. With regard to the map we cannot speak highly: though on it was attempted more than on Phillips's map of 1853, namely the tracing of the subdivisions of Lower, Middle, and Upper Lias, yet in reality far less was accomplished; for all that is correct in it had been more correctly laid down in Phillips's map by means of his notices of where the Middle Lias occurred, and all the additions or differences are purely imaginary; and in *every* case we have found, where comparison was possible, that Bewick was wrong and Phillips was right. This map is, therefore, worse than useless; it is a step backward and actually misleading, as far as its outline topography allows it to lead at all; and if any one were to take this map as a guide to the position of workable ironstone, or its amount, they would be sadly mistaken. But though we speak thus of the map, which represents what Mr. Bewick has *not* seen, we must bear testimony to the accuracy with which he describes what he *has* seen, which, indeed, has sometimes been of use to us.

1865–8. Mr. Simpson published, in a small handbook called 'A Guide to the Geology of the Yorkshire Coast,' "a section of the Yorkshire Lias" as seen between Whitby and Peak. Its chief value is its localizing the various fossils before named by the author. It consists of a description of every bed of the Lias, with their respective thicknesses, and the included fossils. In some parts it fairly represents the truth; but in others it is not possible to follow it at all on the spot, and, as portions of the series appear to be omitted, gives no true idea of the total thickness.

1869. Prof. Phillips, after having, in previous volumes of the Palæontographical Society, described the Liassic Belemnites, and among them those of Yorkshire, in the volume for 1868 (published in 1869) gave a section of the Yorkshire Lias between Saltwick and Saltburn, with special reference to the position of the species of Belemnites described, but also giving the positions of other fossils, but not in this latter doing more than Hunton had done long before.

1871. At the meeting of the British Association at Edinburgh one of us read a paper "On the Yorkshire Lias, and the Distribution of its Ammonites," which was merely an outline of one portion of the researches which in our joint hands issue in the present work.

1872. And the same may be said of another paper, in the Quarterly Journal of the Geological Society for 1872, on the Infralias in Yorkshire, by the same writer.

1875. A third and, unhappily, posthumous edition of Phillips's 'Geology of the Yorkshire Coast.' The main additions in this issue

do not refer to the Lias, with respect to which but little has been done; and what has been added may be considered as a résumé of facts previously published by the author or others, while the distinct colouring for Middle Lias has been omitted from the map.

II. *List of the Principal Works on the Descriptive, Chemical, and Economical Geology of the Yorkshire Lias.*

a. SPECIAL.

ALLISON, T. "The Whin Dyke of Cleveland." Trans. Lit. and Phil. Soc. of Cleveland, vol. i. (1869), 4 pp. 2 plates.

BELL, J. L. "On the Cleveland Ironstone." Colliery Guardian, vol. xxiii. p. 607: 1863.

BEWICK, J. "Geological Treatise on the District of Cleveland," 1861.

BIRD. *See* YOUNG & BIRD.

BLAKE, J. F. "On the Yorkshire Lias, and the Distribution of its Ammonites." British Assoc. Reports, 1871.

——. "On the Infralias in Yorkshire." Quart. Journ. Geol. Soc. vol. xxviii. pp. 132–147: 1872.

BOWER, JOHN A. "Whitby Jet and its Manufacture." Journ. Soc. Arts, vol. xxii. pp. 80–86: 1873.

CROWDER, W. "On the Chemical Composition of the Cleveland Ironstone Beds." Edinburgh New Phil. Journ. 1856.

——. "On the Average Composition of Rosedale, Whitby, and Cleveland Ironstone." *Id.* 1857.

HUNTON, LOUIS. "Remarks on the Section of the Upper Lias and Marlstone in Yorkshire." Trans. Geol. Soc. 2nd ser. vol. v. 1836.

MARLEY, JOHN. "Cleveland Ironstone." Trans. N. of England Inst. of Mining Engineers, vol. v. 1857.

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CHAPTER III.

RANGE, EXTENT AND GENERAL CHARACTERS OF THE YORKSHIRE LIAS.

YORKSHIRE is divided longitudinally by a great depression or plain, scooped out of the yielding marls of the Keuper series, along the centre of which the North-Eastern Railway runs by Selby, York, Thirsk, Northallerton, and Stockton. On the west of this plain we have the hilly regions of part of the North and West Ridings formed by the Carboniferous and Permian rocks, and on the east another, less lofty but still hilly region comprising within its boundary the well-known moors and wolds.

This eastern side may be again separated into divisions nearly corresponding to the North and East Ridings. Through the latter run the chalk wolds, a far more modern set of hills than their higher and more northern neighbours, and which overlap all the underlying strata successively from the Lias to the Neocomian. The older group of rocks occupies somewhat of a basin-shaped area, broken into on the east where the Vale of Pickering opens into the sea between Filey and Flamborough Head. Throughout this area, though the various rocks of the series are differently developed in thickness and importance, yet the higher are on the inner edge of the basin, and they are surrounded by the older strata, which thus successively present a longer range, till the lowest, or Liassic, have the longest and widest range of all.

The northern portion of this basin is far more largely developed than the southern, especially the beds immediately above the Lias, *i. e.* the Inferior Oolite: these, in the north, spread out into moors of twenty miles breadth, but in the south scarcely cover two miles of country; but everywhere they are supported by the Liassic strata, which dip inwards on all sides. It would be rash perhaps to assert that the Lias and other strata were here deposited in a basin-shaped area; but they certainly present that appearance now round more than half the circumference. Although the total area covered by Lias in Yorkshire is but a small fraction of the whole, yet this is by no means in proportion to the part it has played in the structure of the country; especially is it so in the northern portion, where large tracts possess only a thin coating of Oolite rock, whilst the main mass of the wide open moor is supported by the Lias, which is only brought to light, however, in the sides of the deeper valleys.

Tracing round the circumference of this basin, the Lias first makes its appearance at Blea Wyke on the coast; and by a local disturbance and elevation a little to the north of this, in Robin

Hood's Bay, a considerable portion of it is exposed; but it soon ceases to form the surface of the ground, and from the Bay to Whitby it is entirely covered by the Inferior Oolite and can only be studied (though there to great advantage) in the cliff sections. Continuing northwards, it still appears only in the cliffs and in the bay- and inlet-like areas of varying extent running in from the sea, as at Sandsend, Runswick, Staithes, and Skinningrove. Lastly, at Huntcliff, near Saltburn, it throws off its Oolitic burden, and becomes a surface-rock over many square miles. From this point and all along the west escarpment of the moorlands it is more fully exposed, but nowhere so much as in the north-western portion, where also many of its beds are most fully developed, and its commercial importance, from its yield of ironstone, reaches its maximum. It is here too that it attains its greatest elevation above the sea in Great Britain, namely 1200 feet in the hills south of Stokesley. The escarpments which it forms in this western portion are magnificent, decreasing, however, to the south, till by the time it has reached the latitude of Thirsk it has sunk into insignificance; throughout this course it presents an average breadth of about three miles. Beyond this point it is much covered with superficial deposits (boulder-till and warp), as it is, indeed, throughout its northern and western range, on the lower parts, and is only to be discovered here and there in chance exposures; so that our knowledge of its upper limit is greatly guided by the range of the lowest beds of the Inferior Oolite, and the lower limit becomes rather conjectural. This is more especially the case south and east of Easingwold, until we enter the East Riding, where another set of features appear, which are unconnected with the basin-shaped area we are now delineating. We have hitherto refrained from mentioning some remarkable inliers of Lias, which form the bases of two series of vales, and are quite a study of themselves. The northern series of these vales, viz. Westerdale, Danby Dale, Fryup, Glaizedale, and Eskdale, are drained by the Esk, which carries their waters northwards. The southern series, including Bilsdale, Bransdale, Farndale, and Rosedale, are drained by tributaries of the Derwent, which carries their waters southwards to the Humber. Without entering here into details which will be better given afterwards, these facts reveal the existence of an anticlinal coincident with the watershed, which is also borne out by observation, and prove that on the north the beds dip north on the whole, and on the south dip south, at a greater rate than the fall of the rivers.

It is thus in the North Riding that the chief development (or, at least, exposure) of the Liassic beds takes place. In the East Riding the case is different; here the Lias is everywhere conformable to the underlying Keuper, but for some distance is overlain unconformably either by the Oolite or the Chalk, and can only be traced as a narrow strip where it may chance to emerge between the more widely spreading rocks. Nevertheless it is never lost sight of; the line is continuous, though consisting, as might be supposed, chiefly of the lower portions. We are not, however, to suppose that the upper portions are wanting, as they are only covered up and are occa-

Divisions adopted in this work.		Oppel. 1856.	Wright, 1860.
INFERIOR OOLITE.	Blea-Wyke beds.	Inferior Oolite, zone of *A. torulosus.*	Upper Lias sands.
UPPER LIAS.	Zone of *Ammonites jurensis.*	Not recognized.	
	Zone of *A. communis.*	Zone of *Posidonomya Bronnii.*	Alum shale.
	Zone of *A. serpentinus.*		
MIDDLE LIAS.	Zone of *A. annulatus.*		
	Zone of *A. spinatus.*	Zone of *A. spinatus.*	
	Upper zone of *A. margaritatus.*	Upper zone of *A. margaritatus.*	
	Lower zone of *A. margaritatus.*	Lower zone of *A. magaritatus.*	
	Zone of *A. capricornus.*	Zone of *A. Davœi.*	
	Zone of *A. Jamesoni.*	Zones of *A. ibex* and *A. Jamesoni.*	
	Region of *A. armatus.*		Zone of *A. Jamesoni.*
LOWER LIAS.	Zone of *A. oxynotus.*	Zone of *A. raricostatus.*	Zone of *A. raricostatus.*
		Zone of *A. oxynotus.*	Zone of *A. oxynotus.*
		Zone of *A. obtusus.*	Zone of *A. obtusus.*
	Upper zone of *A. Bucklandi.*	*Tuberculatus* bed. These divisions established on inference only.	
	Middle and Lower zone of *A. Bucklandi.*	Zone of *A. Bucklandi.*	
	Zone of *A. angulatus.*	Zone of *A. angulatus.*	
	Zone of *A. planorbis.*	Zone of *A. planorbis.*	
RHÆTIC.	*Avicula-contorta* beds.	Not recognized.	
KEUPER.			

<table>
<tr><th>Young and Bird, 1828.</th><th>Phillips, 1829.</th><th>Hunton, 1836.</th><th>Simpson. 1868.</th></tr>
<tr><td>Dogger.</td><td>Oolite.</td><td>Oolite.</td><td>Oolite.</td></tr>
<tr><td>Main Bed of Alum Shale.</td><td>Alum Shale.</td><td>Alum Shale.</td><td rowspan="3">Alum Shale.</td></tr>
<tr><td>Sandsend Beds.</td><td>Hard Lias Shale.</td><td>Jet Rock.</td></tr>
<tr><td>Hard and compact Alum Shale.</td><td>Softer Alum Shale.</td><td>Hard compact Shale.</td></tr>
<tr><td>Kettleness Beds, Upper part.</td><td rowspan="2">Ironstone Series.</td><td rowspan="3">Marlstone Beds.</td><td rowspan="2">Ironstone Series, or Kettleness Beds.</td></tr>
<tr><td>Kettleness Beds, Lower part.</td></tr>
<tr><td>Staithes Beds.</td><td>Marlstone.</td><td>Staithes Beds.</td></tr>
<tr><td>Lowest Alum Shale.</td><td rowspan="2">Lower Lias Shale.</td><td>Lower Lias Shale.</td><td>Lower Lias.</td></tr>
<tr><td></td><td rowspan="3"></td><td>Indurated bands of Lower Lias.</td></tr>
<tr><td>Lowest Alum Shale.</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Red Sandstone.</td></tr>
</table>

CHAPTER IV.

RELATIONS OF THE LIAS AND INFERIOR OOLITE.

The Oolitic character of the Blea-Wyke beds and their equivalents.—When the Oolite rests conformably on the Upper Lias, as is generally the case in the northern and also in the extreme southern portion of our area, we find great variety manifested in the character of the junction. In most localities Oolitic rocks, generally ferruginous, rest immediately upon the alum-shale series—though in some instances they so gradually change in character as to make it difficult to draw the line, showing, indeed, that the deposition was continuous, though vast lengths of time were occupied. In one locality, however, at least, Blea Wyke, there are found some intermediate beds containing a peculiar assemblage of fossils not elsewhere met with, and showing even a more gradual and complete passage between the two series of rocks.

The lithological reasons for drawing the line of junction elsewhere, here, to a certain extent, fail, and we are thrown back chiefly on palæontological evidence. Does its guidance teach us that we have drawn our line elsewhere wrongly, and that we ought to have included some of the oolitic rocks in the Liassic series? This has been maintained by Dr. Wright, and accepted by many; but, apart from the great inconvenience of having so marked a discrepancy between the results of palæontology and lithology, and of drawing the line between two great formations in the midst of rocks of exactly the same character, while a marked line of distinction occurs a few feet below, we are of opinion that the contrary is the result of palæontological evidence, and that this agrees in its teaching with that of the lithology. It is plain that we must settle this question before discussing the range of the upper limit of the Lias.

At Blea Wyke, on the coast, a short distance south of the Peak, and the most easterly point of exposure of Liassic strata, we have the following section (p. 19) in descending order, as given by Dr. Wright.

Dr. Wright, whose description (Quart. Journ. Geol. Soc. vol. xvi. p. 3) of the upper beds of this section we have exactly followed in the above, excepting the addition of some fossils, would draw the line between the Inferior Oolite and Lias, between beds No. 1, and No. 2, whereas, we would draw it below No. 5; and therefore it becomes necessary to discuss the question whether beds Nos. 2–5 are to be considered Liassic or Oolitic—on palæontological grounds. The Ammonites are considered by Dr. Wright the most important

	Thickness. ft. in.	Lithology.	Characteristic Fossils.
		Higher beds of Inferior Oolite.	
Blea-Wyke* beds.	5 0	1. Yellowish sandstone.	*Monotis substriatus, M. inæquivalvis.*
Blea-Wyke* beds.	1 6	2. Dark friable shale and ironstone.	*Terebratula trilineata, Bel. compressus, B. irregularis, Gresslya peregrina, Trigonia Ramsayi, Rhynchonella cynocephala.*
Blea-Wyke* beds.	20 0	3. Yellow sandstone.	*Am. insignis, A. comensis, Turritella, Trigonia, Astarte, Monotis inæquivalvis, Goniomya angulifera, Gresslya pinguis, Glyphæa Birdi.*
Blea-Wyke* beds.	10 0	4. *Serpula* bed. A fine-grained, greyish-yellow sandstone.	*Am. aalensis* (var. *Moorei*), *Vermetus compressus, Serpula diplexa, Gresslya peregrina, Dentalium elongatum, Lingula Beanii, Cardium striatulum.*
Blea-Wyke* beds.	20 0	5. *Lingula* bed. A soft argillo-micaceous sandstone, with a line of sandy micaceous nodules at the base.	*Am. aalensis, A. comensis, Bel. compressus, B. irregularis, Cerithium quinquepunctatum, Cucullæa cancellata, Gervillia Hartmanni, Pholadomya fidicula, Monotis substriata, Pecten silenus, Gresslya peregrina, Pinna cuneata, Lingula Beani, Rhyn. cynocephala, Discina reflexa, Terebrat. trilineata, Glyphæa Birdi,* &c.
Upper Lias.	70 0 or 80 0	6. Shales, with layers of nodules.	*Am. striatulus, A. insignis, A. varibilis, A. jurensis, Bel. ventralis, Monotis substriata, Lima Toarcensis, Ostrea subauricularis, Pecten disciformis, Leda inæquialtera, Trigonia litterata, Rhynchonella jurensis,* &c.
Upper Lias.		7. Alum shale.	*A. communis, A. bifrons, Trigonia litterata, Monotis substriata, Leda ovum,* &c.

witnesses, as, on their evidence on the question in the Gloucestershire district, he overthrows the unanimous testimony of the other Mollusca to the Oolitic character of corresponding beds. What evidence do they afford here? From bed No. 3 he quotes *A. insignis* and *A. comensis*, both reckoned Liassic species; from No. 4 *A. aalensis*, and from No. 5 *A. aalensis* and *A. comensis*; while he also records *A. insignis* and *A. aalensis* from the nodules in No. 6.

* Incorrectly written Blue Wick in Dr. Wright's paper.

First, with reference to *A. insignis.* This Ammonite is excessively rare in the Lias beds No. 6; but we have no doubt of its occurrence there. The sutures, however, differ from those given by D'Orbigny for *A. insignis*, in being far more simple; there is, moreover, a closely allied form known in the Inferior Oolite, called *A. subinsignis* by Oppel, to which D'Orbigny's specimen and those from bed No. 3 may very probably belong.

Secondly, with regard to *A. aalensis* and *A. comensis.* The common Ammonite in beds Nos. 4 & 5 is undoubtedly *A. Murchisonæ.* These three, however, are very difficult to distinguish, even if they be really distinct, which is, perhaps, doubtful.

In point of fact *A. Murchisonæ, A. aalensis, A. comensis, A. variabilis*, all belong to one alliance, and may be confounded with one another; very little reliance can therefore be placed in the names given in lists. On the whole, the evidence of the Ammonites amounts to this, that a certain family of them (and we may even include *A. insignis* in the category) began their existence before the great number of other Mollusca that came to be associated with them in Oolitic times; and if we were guided by this alone, it would be rather to lower the line of junction beneath the shales with *A. striatulus* than to raise it any further.

Again, with regard to the Liassic Belemnites, *B. compressus* and *B. irregularis* are said to occur in these disputed beds; the presence, however, of the latter is not confirmed by Phillips in his Monograph on the British Belemnites; and he makes the so-called *B. compressus* a distinct species under the name of *B. inornatus*, separated by the absence of any ventral groove. Of the remaining fossils *Terebratula trilineata, Rhynchonella cynocephala, Gervillia Hartmanni, Pholadomya fidicula* are characteristic species of the Oolite here and everywhere. *Lingula Beanii* is nowhere found in the Upper Lias; *Vermetus compressus, Serpula diplexa*, and *Glyphæa Birdi* are peculiar to these beds; while there are left *Discina reflexa* and *Monotis substriata*, which are undoubtedly Liassic species, and are certainly continued into these beds. We have thus analyzed the evidence brought by Dr. Wright, and submit that it affords no good reason to separate these beds from the Oolite to which they lithologically belong; but rather, when we consider the many new forms which are first introduced, more in number even than those that have passed up, and the *prevalence* of a new form of Ammonite, which had only appeared as an allied species before, we have, it appears to us, good grounds for believing that a change of life-forms took place —*not* in the middle of the deposition of sandstone rock, but when it first began after the deposition of shale. We therefore, in this place, draw the line between the Lias and Oolite at the base of bed No. 5, below its lowest set of nodules, as was done by the older authors, and more recently by Oppel (1856) and Simpson (1868); and for us Liassic strata are shaly to the top.

It has been necessary to enter into details on this point, that we may fix our line once for all. The other sections we can then interpret easily, while they corroborate our conclusions above, and, in fact, render any other almost impossible and absurd.

Briefly, then, there is everywhere found underlying the lowest freestone of the Inferior Oolite a series of beds, variable in thickness and in mineral condition, which contain marine fossils belonging to characteristic species of the Lower Oolite. Generally the strata consist of sandy shales containing bands, or doggers, of ferro-arenaceous limestone, which, however, over certain areas acquire considerable development, assuming the form of a massive arenaceo-ferrous rock. This ironstone, which is of little commercial value, though mined at a few places, is known as the TOP SEAM, and, when fossiliferous, contains the same species as the Blea-Wyke beds, and by its organic contents and stratigraphical position is the equivalent of the Ironstone beds of the Northampton Sand—the propriety of attaching which to the Inferior Oolite is obvious on studying the lists of fossils given by Mr. Sharp (Quart. Journ. Geol. Soc. vol. xxvi. p. 385).

In all the sections, excepting that at Blea Wyke, these Oolitic shales and ironstones rest immediately on the alum shale; whilst at that place 70 or 80 feet of shales with cement nodules containing *Ammonites striatulus* intervene. These we consider to be the only representatives of the zone of "*Ammonites jurensis*" in Yorkshire. Where these are absent, there must have been a cessation of deposit —an interval of rest; and it seems at any rate more natural that this should mark the close of the Liassic period. Indeed this is not the only instance of the truncation of the Upper Lias, inasmuch as, in its southerly range along the western escarpment, the upper part of it alone seems to be diminished in thickness; but throughout it is covered by the Oolitic shales and ironstones,—phenomena which are sufficient to establish the line of separation as we have drawn it. More decided evidences of unconformability, of a local character only, can, however, be adduced. The most striking example is presented by the outlier of Cold Moor between Bilsdale and Raisdale; on its S.E. escarpment the base of the Inferior Oolite consists of a fissile limestone above, largely made up of the débris of Encrinites and Cidarites, and a ferruginous sand rock several feet in thickness below, between which and the jet rock a thickness of only 25 feet of Alum shale intervenes. This feature may be studied behind the farmsteads of Cock Flat and Bank House, and indicates an eroded surface of the Upper Lias, the axis of the minimum thickness coursing in a nearly N.E. direction, through Round Hill at the southern extremity of the outlier, about one mile in length of which is preserved. The escarpment beyond Bank House trends to the north, and the Upper Lias is seen to acquire gradually its full thickness; this circumstance precludes an interpretation of the phenomenon by the existence of a fault or faults, even were it not known that the jet-workings penetrate far beneath the Oolitic cover.

The basin of the magnetic ironstone in Rosedale is evidently an analogous phenomenon.

Sections of the Junction beds between the Lias and Oolite.—The sudden changes from shale to ironstone render it difficult to trace out systematically the geographical distribution of the ferruginous development of the Blea-Wyke beds, which, however, does not pro-

perly come within the scope of this memoir, though it is desirable, for reasons already explained, to give other sections illustrative of the junction of the Lias and Oolite.

At Saltwick, near Whitby, the junction is very simple.

Inferior Oolite.		Freestone block.	
		Carbonaceous sandy shales.	Numerous Ferns.
	2 ft. 8 in.	Ironstone band with dogger below; about 8 or 10 in. with pebbles; fossils very few and badly preserved.	*Cardium acutangulum* (Ph.), *Gresslya*, sp., Wood.
Upper Lias.	9 ft. 6 in.	Hard blue shale.	*Ammonites mucronatus* (?), *A. complanatus*, *Belemnites Voltzii*, *B. subaduncatus*. *A. variabilis* and *A. bifrons* at a depth of 5 feet.
		Cement-stones &c.	

On the road-side approaching East Row from Whitby, and distant about 4 miles from the last section, the basal part of the Inferior Oolite is exposed, consisting of sandstone with agglomerated iron-masses 6 feet 6 inches, arenaceous ironstone 5 feet, sandy shales, passing into alum shale.

The section exposed at the Peak New Alum-works is very similar to that of the Whitby Cliff, though within half a mile of the totally different junction at Peak Steel. There is a great fault which cuts off the latter; and it seems to have nearly coincided with the edge of an area of deposition. As we pass up the valley of the Esk, we find in the neighbourhood of Sleights the first signs of that top band of ironstone which in Glaisdale, and far to the west, caps the Lias, and acquires some importance as an ore. In the Sleights New Alum-works we have the following section:—

	ft.	in.
1. Massive freestone, cross-jointed, in places flaggy for the lower 1–3 feet	25	0
2. Carbonaceous sandy shale	2	4
3. White sandy bed, similar to that containing the *Equisetum* at Whitby, graduating into	1	3
4. Sandy beds splitting into irregular layers, partly carbonaceous, with thin shaly layers	3	9
5. Concretionary sandstone, with irony junctions ...	4	0
6. Solid sandstone, concretionary at the top, three or more courses, irregular ferruginous partings, but scarcely an ironstone	9	4
7. Sandy shale, white band at the top	2	9
8. Shale, nodular band 1 foot, gradually becoming true alum shale at less than 30 feet. *Am. communis*, *Monotis substriata*	56	0

Here Nos. 5 & 6 are undoubtedly the representatives of the ironstone band of 2 feet 8 inches at Whitby, showing how it has swelled; but it is still not fossiliferous, or very sparingly so. The peculiar concretionary structure, however, shows its relation to the

sections further west, where this character is more fully developed. The Lias shale also differs from that at Whitby in changing its character towards the top, in this section becoming very sandy, showing the change to be here more gradual, and that we have more beds intercalated.

On the opposite side of the valley, in a beck just west of Aislaby village, is another section showing the junction; and though the face is rather disturbed and broken, it is a remarkable one.

	ft.	in.
1. Thick sandstone rock	10	0
2. Concretionary sandstone	3	0
3. Shale, with many lines of blue Oolitic doggers ...	5	0
4. Double sandstone band, fossiliferous. *Belemnites*, *Pecten disciformis*, *Trigonia striata*, *Modiola plicata*	1	8
5. Lias shales, with indurated bands. Fossils scarce. *Bel. irregularis*, *Gresslya*	6	0

Here the line must be drawn below No. 4, which seems to be a thickened and fossiliferous representative of the nodular band of No. 8 in the last section, showing that the Lias is here followed by beds which are similar lithologically, though differing in their fossils; and, indeed, it seems necessary to remark that the apparent junction of shale and stone is often not the upper limit of the Lias, but that, at some varying distance down this shale, another fossiliferous stone band occurs of comparatively slight thickness, which is the true base of the Oolite—proved so, as it seems to us, by the presence, in various localities, of many of the most characteristic Inferior Oolite fossils.

In these cases it is a palæontological line that we draw; but instead of raising it above Oolitic beds, we depress it into the midst of shales. We are far from asserting that the lines drawn in various localities as the top of the Lias represent the same exact epoch of time, but only that, in each locality, when the top bed thus marked off had been deposited, the conditions of the Oolitic period had set in before the deposition of the next.

A typical section of these junction beds is that at Beck Hole, at the head of Goathland; it is as follows:—

INFERIOR OOLITE.	ft.	in.
1. Thick-bedded sandstone.		
2. Arenaceous ironstone	10	0
3. Ferruginous sandstone	1	6
4. Sandy shales, with a dogger band in the middle .	1	6
5. Dogger band	0	9
UPPER LIAS.		
6. Black shale, like alum shale, with scattered doggers	23	0
Ammonites crassus and *Monotis substriata* found in this bed at a depth of 20 ft.		

In the valley of Glaisdale the basement beds of the Oolite are seen to advantage along its sides, especially on Snowdon Nab, and consist of a sandy ferruginous stone about 12 feet, and coarse

sandy shales passing into ordinary alum shale—the change complete at a depth of 7 feet. At the now abandoned mines of the Top Seam the section is not well enough exposed to throw further light on the junction.

From the fossils, however, of the ironstone which Dr. Wright claims as Lias, *i. e.* as equivalent to the beds in dispute at Blea Wyke, we obtain valuable information. Here *Rhynchonella cynocephala* and *Terebratula trilineata* are associated in great numbers with such fossils as *Ostrea flabelloides, Ceromya concentrica, Pholadomya Heraulti, Rhynchonella subtetraedra, Modiola cuneata, Alaria composita*, which prove the first-named fossils to be characteristic of beds full of Oolitic species, and equivalent to the lowest fossiliferous stone band of the Inferior Oolite, as occurring at Aislaby and elsewhere.

In the next vale, however, at Great Fryup Head, though the spot is rather inaccessible, one of the finest sections possible is exposed, making perfectly plain in that district the relations of the two formations. It is as follows:—

	ft.	in.
1. Thick-bedded sandstones with wood	50	0
2. Thin flaggy sandstone, thicker at the base	15	0
3. Thick-bedded sandstones	16	0
4. Carbonaceous shales	6	0
5. Concretionary sandstones with ironstone junctions	13	9
6. Hard blue shale, rough and irregular	4	6
7. Dogger beds, with nests of small decayed fossils—*Belemnites, Pentacrinus, Pholadomya, Pecten lens?, Pinna*	6	6
8. More shaly black-coloured beds; in the lower part several fossiliferous nodules—*Avicula Munsteri, Pholadomya*	5	6
9. Harder stone band, with fossils—*Bel. giganteus*	1	0
10. Bluish white, irregularly shaly beds, very crumbly, with *Gresslya abducta* (?) (vertical), at 24 feet down. *Monotis substriata* at 30 feet, whence downwards it is quite blue and regular alum shale	70	0

In this section, instead of 1 foot 8 inches of ironstone, as at Whitby, between the carbonaceous shales and the *Lias*, we must here reckon five beds of united thickness 34 feet 3 inches; it would appear that No. 5 represents the top seam of ironstone, here of great thickness, but that we must draw the upper line of Lias above the top of No. 10, leaving 17 feet 6 inches between. Other sections in the same vale, as at Jackdaw Crags and Stanch Bullen, give similar results, but need not be here repeated.

Another most instructive section, however, which may be seen in Danby Dale under "Bakers Nab" or "Double Dyke," a more accessible spot, must not be omitted.

	ft.	in.
1. Thick-bedded freestone	8	0
2. Coal shale	5	6
3. Freestone, becoming thin-bedded at the base, and containing a 9-inch concretionary band of ironstone	12	0

	ft.	in.
4. Blue shale, very like alum shale, but rougher and more micaceous	6	6
5. Rubbly ironstone, with fossiliferous nodules; nodular for 6 inches; more shaly band 2 feet; irregularly broken ironstone. *Monotis-substriata* band	7	6
6. Rubbly irregular clayey stone, changing insensibly to alum shale at 30 feet, with nodules	80	0

Here the various portions of 5 are the equivalents of Nos. 7, 8, 9 in Fryup Head, and show that this band is diminishing again. The fossils are very numerous and remarkable:—

Ammonites Murchisonæ.
Chemnitzia, Macrodon, Turbo.
Pholadomya Heraulti.
Pecten lens.
Hinnites velatus.
Terebratula trilineata.
Cardium striatulum, *Ph.* (non *Sow.*).
Trigonia costata (?).
—— striata.
Avicula Münsteri.
Monotis substriata.
Rhynchonella Crossii.
—— cynocephala.

This is seen to rest immediately on the Lias, in which there are some rotten nodules, which *may* represent the *striatulus*-beds on the coast; it is undoubtedly the equivalent of the Glaizedale ironstone.

These same fossiliferous beds, with similar fossils, are seen in the bank of the stream on the east side of Castleton, north of Howe Hill, where we have the following section:—

	ft.	in.
1. Black shales, with coal-smut		
2. Black shales		
3. Sandy ferro-argillaceous limestone, breaking into cuboidal pieces; a shaly parting divides it into two courses; the upper band contains small concretions	1	6
4. Sandy micaceous shales—*Gresslyæ* and *Pinna* ...	5	0 seen.

A few yards to the south the alum shale appears.

The fossils of No. 3 are as follows:—

Ammonites Murchisonæ.
Dentalium elongatum.
Pholadomya Heraulti.
Goniomya angulifera.
Gresslya abducta.
Cardium striatulum, *Ph.*
Trigonia pulla (?).
Cucullea cancellata.
Tancredia, sp.
Pecten vimineus.
—— disciformis.
Pinna, sp.
Monotis substriata.
Ostrea Sowerbyi.
Clypeus, sp.
Pentacrinus.
Clione.

As it is only in this northern portion of the district that these junction beds have their full development, or that sufficiently instructive sections may be found, we shall give one more illustrative of this point, viz. that to be seen at the Lofthouse Alum-works.

Section measured on the west side of the Bay in the cliff due north of the Hamlet of Upton.

	ft.	in.
1. Soil	4	6
2. Boulder-clay *	9	6
3. Sandy shales	3	6
4. Black shales, with coal-smut	3	0
5. Sandy shales	1	6
6. White brashy sandstone	3	0
7. Greyish-blue sandy micaceous shales—jet	4	6
8. Bluish shales, micaceous and sandy, with thin sandy calcareous layers—jet	10	4
9. Impure limestone dogger	0	3
10. Shale—*Ammonites Murchisonæ*	1	6
11. Impure limestone dogger—zinc-blende, iron-pyrites	0	3
12. Sandy shale	2	0
13. Band of small cylindrical nodules of impure clay ironstone; 14. Band of ferro-argillaceous limestone—*Gresslya donaciformis*, *Belemnites subaduncatus*	1	2
15. Sandy shale, with rounded concretions in middle.	4	6
16. Shale somewhat sandy, with cement-stone nodules	6	3
17. Blue shales, with *Ammonites crassus*, *A. bifrons*, *A. fibulatus*, *Trigonia litterata*, *Gresslya donaciformis*, *Belemnites vulgaris*.		

Here we encounter a considerable thickness of sandy argillaceous beds beneath the main block of sandstone, low down in which is the ever-recurring fossiliferous band No. 11, containing the same general assemblage of species. How far below it the line should be drawn is difficult to say; the two fossils in No. 14 are Liassic species; but the smooth character of the ordinary alum shale is not exhibited till bed 17 is reached, and it may be convenient to regard No. 15 as the base of the Oolite.

Fossils of bed No. 11.

Belemnites.
Actæon Sedgvici.
Actæonina mitræformis, *Braun.*
Dentalium entaloides, *Desh.*
Ostrea flabelloides.
Anomia, sp.
Plicatula.
Lima toarcensis.
Pecten lens.
Mytilus imbricatus.
—— cuneatus.
Perna isognomoides, *Stahl.*
Leda rostralis, *Lamk.*
Cucullæa cancellata.
Corbula.
Quenstedtia oblita.
Entomostraca.
Serpula.
Pentacrinus.
Alethopteris polypodioides, *Lindl.* ?, fragments of pinnules with sori.

The following section, measured at the eastern end of the Boulby Alum Quarry, one mile and a quarter from the last, exemplifies the extreme variability in the mineral condition of these Oolitic beds.

	ft.	in.
1. Sandstones	58	0
2. Shales, with coal-smut	2	6

* About 12 feet of shales and the main sandstone have been denuded.

		ft.	in.
3.	Rubbly sandstone	6	6
4.	Coaly shales	17	0
5.	White sandy shales	7	0
6.	Grey sandstone	38	0
7.	Ferro-argillaceous sand rock, with marine fossils.	1	0
8.	Grey sandy shale, with ferro-argillaceous stone bands ....about	7	0
9.	Alum shale.		

Bed No. 7 would seem to be the equivalent of No. 11 in the Lofthouse Quarry, whilst the overlying shales in that section have run out or in part merged into the lower block of sandstone, No. 6.

Range of the upper limit of the Lias.—Having said so much upon the right position of the junction between the Lias and Oolite, we will now trace its range throughout our area.

After rising from the shore at Blea Wyke, and reaching an elevation of nearly 300 feet, it is suddenly thrown still higher by a great dislocation, on the west side of which it occurs at a height of 600 feet, but not maintaining, as mentioned before, the same characters. It is here well seen in the magnificent artificial escarpments of the Peak and Brow Alum-works; it gradually sinks, however, from the dislocation, so that on the sides of Howdale Beck it is only at 500 feet; from thence it sinks far more rapidly, and in less than a mile westward the junction is seen in a stream at an elevation of 280 feet only, which it maintains for half a mile to the north; here, however, the line of junction, continuing northward, rises as rapidly to 500 feet at Park Gate, descends 100 feet to Row, and sweeps round the north of Robin Hood's Bay at the same elevation till it turns northward again and descends into the cliff a little south of Hawsker Bottoms. This line of range shows the existence of a large synclinal axis, with the beds dipping down on either side at 5° to 8°—exactly the contrary phenomenon to that which is presented on the coast, showing that the exposure of the Lias here is due to a centre of elevation somewhere beneath the sea, nearly opposite to the middle of the bay.

After passing Robin Hood's Bay the Lias is no more seen on the surface, and gradually descends lower in the cliff, the Oolite reaching the shore at two places; after some gentle undulations it is beginning to rise again at Whitby Harbour, when it is cut off by a downthrow fault of 75 feet, so that on the north of the harbour only Oolite is seen. Thus, though Whitby is celebrated for its Lias cliffs, it so happens that not a single house of the town stands upon that formation. Robin Hood's Bay is a complete inlier; it may, indeed, be considered as the most easterly of a series of such inliers, which are caused by certain elevations and dislocations, and of which the dales of Westerdale, Danby Dale, Fryup, Glaizedale and Eskdale are the more westerly; but as it appears on the coast it comes in for description first. Were it not for these subsequent disturbances, the Oolites would occur all the way to Sandsend, past Whitby, and the Lias would

gradually rise to its westerly escarpment by Eston and Stokesley, to be succeeded in regular course by the Keuper. The Lias, then, in its continuous development appears first about three miles from Whitby, at Raithwaite, near Sandsend; the cliffs further north are all composed of it; and the alum-works are excavated in the upper part. It only appears inland, however, in two narrow gorges worn by two streams which reach the sea at Sandsend, the sloping banks formed of alum shale being covered with trees and forming the picturesque woods of Mulgrave Castle; the junction of the two formations is seen at Hall Scar and Biggersdale Hole. On reaching Clay-Moor End, at the south-west corner of Runswick Bay it turns inland, but is not traceable for more than half a mile along the edge of Clay Moor; it now is deeply buried beneath Boulder-clay which fills a broad depression extending westward towards Rousby and Boulby and Borrowby, soon after which it is again seen at the surface, showing on the north an Oolitic outlier on which Runswick and Hinderwell stand.

The Upper Lias again forms a deep valley, divided into two parallel gorges by a tongue of Boulder-clay partially supported by a small outlier of Oolite, at Rousby and Easington Becks; west of this, however, the surface of the country rises so high that, in spite of having now reached an elevation of 550 feet, the Lias returns almost entirely to the cliffs, the tops of which at Boulby and Lofthouse Alum-works are in the Inferior Oolite. The gorge of Skinningrove again allows it to run inland; and after passing round the headland to the east of Saltburn, it finally leaves the sea-shore and supports the bold hills which face westward. The country here, however, has been subjected to great denudation, by which two large Oolitic outliers are left, one that of Upleatham, and the other forming Eston and Wilton Moors. In this neighbourhood also the elevation of the main mass is by no means constant, nor does it uniformly rise; on the average, however, it is about 600 feet above the sea. Good sections of the junction beds are afforded in this part of their range at Skelton Alum-works near Saltburn, Rock Hole, Slape Wath, and Cass-Rock Quarry near Guisbro'. After passing Slape Wath, where it runs into the Oolite in a deep bay, it gradually rises along an escarpment facing N.W. to 900 feet at Roseberry Topping. This hill is capped by a small patch of Oolite, forming an outlier, as are also two portions of the neighbouring high ground—Coates Moor and Kildale Moor. The Lias appears here in all the excavated valleys, and runs far in between the hills to the east of Kildale station for more than three miles. To the south of this, opposite Ingleby Greenhow, it forms a magnificent scarped face in Battersby Crags, where it reaches more than a thousand feet elevation. Soon after this the line of junction turns boldly to the west.

The great valley of Bilsdale, being open by two branches on the north, may be said to belong to the main mass of Lias; but we had better pass it by and include it with the closed valleys, with which it has more analogy.

The Lias then passes along the head of Bilsdale by the outliers of

Hasty Bank, Cold Moor, and Cringley Moor, having now reached its highest point at 1200 feet. From hence it again turns south, or, rather, south-west, and loses its elevation as it does so, coming down again to 800 feet at Ingleby Arncliffe; from this point it turns entirely south. It then follows the sinuosities of the hills by Osmotherly, there forming a deep and wide tongue, thence by Cowesby, Kirby Knowle, apparently not cutting off the Knowle itself as an outlier, and on to Feliskirk. Here it has descended to a level of 520 feet, the junction being seen on the Boltby road near Stonecliff Wood. In coming from Osmotherly (there is a good section in the old alum-works at this place), an Oolitic outlier is left to the west of the escarpment surrounded by Upper Lias, and stretching in a narrow strip four miles southwards to Borrowby.

After passing Feliskirk no line of junction can be seen for a great distance, though the ferruginous base of the Oolite is traceable along the scarped front of the low hills in this district; in this way we believe that it makes a détour northwards behind Mount St. Johns, reaching nearly to Boltby; from thence it returns to Thirlby and under Cleaves, where it is less than 300 feet above the sea, unless, as is not quite impossible, the Cleaves Hill be an enormous slip forward of the Oolite over its surface. At all events it rapidly rises again to about a level of 400 feet in the neighbourhood of High Kilburn, as its junction can be clearly traced along the western slope of the hills and in the roadsides beneath that village; about ¾ mile to the south of this it meets with the mass of rocks of newer age let down into it by a disturbance affecting the whole country in the neighbourhood of Coxwold, and mixing the rocks of various ages in a marvellous way; the actual line of junction therefore is faulted back, and, passing by Snape Wood (which contains the lower but not lowest beds of the Inferior Oolite), runs far out to the west, round by Hutton Sessay, to the south of which the Lias runs in again to its natural line; but the junction is a fault.

We find the true junction again at Husthwaite, where it may be easily traced along the hill, gradually rising from Coxwold. It maintains the high ground above Husthwaite till it is again cut off, and then, taking a level of less than 200 feet, runs round a tongue of Oolite that reaches nearly to the Thirsk and Easingwold road. After this it turns east, and, while it is thickly covered by till &c., there is no reason to doubt its running a regular course by Oulston Bank and Brandsby, leaving a small Oolitic outlier at the top of Crayke Hill; and, finally, near Terrington the two formations become unconformable, and continue so for a great distance.

South of Market Weighton the two are again conformable; and the junction emerges from beneath the Chalk halfway between that town and Sancton, at which latter place it meets with a fault which throws it up. Thence it keeps on the west side of the road to South Newbold, where it is upheaved again, thence to South Drewton, where it is depressed by a dislocation, and, proceeding by way of Everthorpe and Brough, gains the Humber, and crosses into Lincolnshire.

CHAPTER V.

THE RHÆTIC SERIES AND THE RELATIONS OF THE LIAS WITH THE KEUPER.

Owing partly to the depth of Boulder-clay which covers the low ground of the valley of the Tees, and partly to the soft nature and commercial unimportance of the rocks which lie near the junction of the Liassic and Keuper formations, the opportunities afforded for the study of that junction are few and far between; and though we are able to record the existence of Rhætic beds in Yorkshire, with their characteristic fossils, yet it is certainly not in this county that they find their best illustration,—so little so, that, however it may be possible or desirable to separate them from the Lias in more southern districts, it is not so here, at least as far as mapping is concerned. All we can do is to give a description of those few sections which show us the junction, and detail the other exposures of beds immediately above or below it which serve to guide us as to its range.

Northern Area.

Nowhere on the surface do the strata of the Lias and Keuper present a section which satisfactorily shows their true succession. Such a one, however, was afforded in the progress of sinking the gypsum-pit midway between Eston Junction and Eston Mines, in 1868. The strata which were then passed through have been tabulated by Mr. W. H. Peacock (Trans. Cleveland Lit. and Phil. Soc. 1870, p. 10), but unaccompanied by any palæontological particulars; and no reasons are assigned for the separation of a certain thickness under the heading of Rhætic. Fortunately, Mr. George Lee, then of Eston, occasionally visited the pit while the work was going on, and collected specimens of some of the rocks met with, taking care to ascertain the precise depths of their occurrence, and their thicknesses. By taking Mr. Peacock's published account and adding to it the particulars collected by Mr. Lee, we are enabled to submit the following section (p. 31), in which the descriptions preceded by an asterisk are furnished by Mr. Lee's specimens.

The occurrence of two of the characteristic shells of the Rhætic in stratum No. 20 is satisfactory proof that this subformation is present in the north-eastern extremity of the Jurassic system in England; but how much of the section described above is to be included under the term cannot be determined. Stratum No. 21, from partaking the character of No. 20, must obviously be associated therewith. The abrupt change in the mineral condition on entering

1. Hallikeld Farm, 1¼ mile E.N.E. from Brompton. In the plantation bordering the stream which flows by the west side of the farm-house are paper-shales weathering brown and containing obscure fossils—possibly *Isodonta Ewaldi*; these are succeeded by other shales and shelly limestones, chiefly constituted of *Pleuromyæ* and oysters belonging to the "*Planorbis*" series.

2. Grey and greenish Keuper marls are seen along the road-side leading south-east from Northallerton to Crosby Cote, just by the tail of the letter *g* in High Thornborough (1-inch Ordnance Survey) and extending 70 yards down the slope of the hill. Flaggy sandstones occur in the bank on the crest of the hill, and are turned up by the plough in the adjacent fields; they contain casts of *Protocardium Philippianum* (*C. rhæticum*) and *Isodonta*, sp. ?

3. In the upper part of the stream-course (called Dibdale), which flows by High Thornborough, 3 furlongs W.N.W. from the last exposure, there are displayed black, laminated, micaceous shales with ferruginous discoloration between the partings, containing *Cassianella contorta*, *Isodonta Ewaldi*, and *Protocardium Philippianum*. The bank on the west side of the stream is capped by shelly limestones (which, from the abundance of a species of *Pleuromya*, we call the *Pleuromya*-limestones), which are vertically about 30 feet above the position of the shales with *Cassianella contorta*. These *Pleuromya*-limestones, which are encountered in several sections, and contain oyster-bands, commence the true Lower Lias. This is the only locality in which they are brought into relation with the Rhætic beds, as, though found in the Eston gypsum-pit, their position was not ascertained. Nevertheless we have not determined the true succession from the *Cassianella-contorta* shales to these limestones.

4. Between Thornton-le-Beans and Thornton-le-Moor, the fields and superficial wells along the edge of the escarpment show fragments of grey, micaceous, Rhætic sandstones reaching 3 inches in thickness.

At the base of the knoll on which Hill-top Farm stands, and on the north-west of it, blue Keuper marls are exposed; and on its summit *Ostrea*-limestones are turned up by the plough; whilst near the stream-course, nearly south-west of the farmstead, a well-sinking revealed black pyritous shale with *Cassianella contorta* and a granular whitish grey sandstone with much pyritous matter, 1½ inch thick. This sandstone contains débris of fish, as also a finely laminated splintery shale adherent to it; but though the remains are plentiful, yet they do not constitute a fish-bed comparable with that in other external localities; associated with the fish are *Cassianella contorta*, *Isodonta*, and *Protocardia*. The excavation seems to have been limited to the Rhætic beds. Scales of *Gyrolepis Alberti* are abundant, associated with teeth of *Acrodus minimus* and *Saurichthys apicalis*.

Southern Area.

1. *Easingwold.*—Among the spoil of a well-sinking in a field

called "Paradise," on the footpath to Crayke, fragments of Rhætic and Keuper rock were abundant; but it seems improbable that the rocks were there *in situ*.

2. *Howsham.*—In Howsham Wood, in a little streamlet-course descending the hill, from near Wood House to the Derwent, are seen many blocks (apparently coming from different beds) of a hard blue crystalline limestone of irregular fracture containing *Cassianella contorta*, *Monotis fallax*, *Modiola minima*, and *Ostrea liassica*; no complete section, however, can be seen. At the back of the same hill in Boon Wood, Mr. Fox Strangways, of the Geological Survey, has found black shales with *Cassianella contorta*. We have met also with black papery shales on the opposite side of the small valley near Nearfield House, but without the characteristic shell.

3. *Bugthorpe.*—In tracing up the strata that appear in Bugthorpe Beck, very shortly after seeing the last trace of the red marls of the Keuper, the river-bed is crowded with blocks of a hard, brown, coarse-grained sandstone; in one of these we were fortunate to find a well-preserved fragment of bone, about 3 inches long, apparently part of the rib of an *Ichthyosaurus*. This is but a poor apology for a bone-bed; but these sandstones must no doubt be on about the same horizon. They lay unmixed with blocks of *Pleuromya*-limestone, which occurred in profusion some little way further up the stream. None of these beds, however, has any exposure *in situ* here.

The Rhætic fossils discovered in Yorkshire are given in the following list; of these *Acrodus minimus*, *Protocardium Philippianum*, *Monotis fallax*, *Modiola minima*, and *Ostrea liassica* pass to higher horizons:—

Ichthyosaurus (bone)	Bugthorpe.
Saurichthys apicalis, *Ag*................	Thornton.
Acrodus minimus, *Ag*...................	Thornton.
Gyrolepis Alberti, *Ag*.	Thornton.
Protocardium Philippianum, *Dunk*..	Thornton; Eston, near Northallerton.
Isodonta Ewaldi, *Bornemann*	Eston; Hallikeld, near Northallerton; Thornton.
Cassianella contorta, *Portlock*	Eston, near Northallerton; Hill-top, Thornton; Howsham, Boon Wood.
Monotis fallax, *Pflücker*	Howsham.
Modiola minima, *Sow*..................	Howsham; Eston.
Ostrea liassica, *Strickland*	Howsham.

Exposures of the Keuper near the Junction.

The most northern in the county is in the cliff on the foreshore of the river Tees near Lazenby station. Here the upper part of the cliff, about 25 feet high, consists of Boulder-clay resting upon hard red marls with greenish-coloured marly limestone, about 6 feet below which are softer red marls with ramifying and intersecting veins of gypsum. Parts of the gypseous stratum stand out from the cliff in hummocky masses about 6 feet in height, forming a grotesque but picturesque foreground (as seen from a distance) to this unimposing front of rock; its uniformity is

further broken by the contrast of colours presented by the dark red of the Boulder-clay, the lighter red and greenish-blue of the marls, and the white and greenish-white of the gypsum.

These New Red Marls dip to 5° S. of S.E., at an angle of about 3°; and from the known character of the upper part of the Keuper, as determined in the Eston gypsum-pit, there is no doubt that the New Red here has not suffered much denudation.

At Lackenby station, a mile to the south-west of the preceding section, the gypsum has been worked from below a cover of about 14 feet of Boulder-clay.

The boring at Middlesborough, made by Messrs. Bolckow and Vaughan in search of water, made known the thickness and character of the Keuper formation in this district. The depth attained was 1313 feet 4 inches, the first 70 feet of which was in superficial deposits, the only covering to the gypseous marls.

In the bed of the stream, above and below the bridge over which passes the turnpike road leading from Ormsby to Stainton, and close to the Ormsby railway-station, are hard red marls, succeeded above by green marls comparable to those situated near the top of the Keuper in certain other localities.

At Stainton, 3½ miles south from Stockton, the gypseous marls are seen in contact with the whinstone dyke.

Several exposures of the New Red may be seen in the bed of the river Leven. This river, from a mile above Hutton Rudby to its confluence with the Tees, flows between high banks composed of Boulder-clay resting on Keuper marls, which form the floor of the valley and are seen rising here and there into low terraces from 10 to 15 feet in height, as at Leven Bridge, Middleton Mill, Hutton, and Rudby. At Hutton Rudby a most conspicuous stratum is a fissile granular marly stone, green and variegated externally, but of a pink colour on the fractured surfaces; at the base of the cliff on which the village stands this rock is about 2 feet in thickness, is overlain by red marls, and superimposed on red marls with gypsum. The Keuper in this neighbourhood exhibits gentle undulations, with a general dip of about 7° to the S. or S.S.E.

The last section of red marls in the line of dip, and approaching to the Liassic area, is in the Potto beck, at about 130 yards below its junction with the Potto slack; it is covered with Boulder-clay.

Passing to the south-west, and hence following the trend of the Jurassic escarpment, the next known position of the New Red marls is halfway between West Rounton and East Harsley, as determined by a well-sinking.

Between this and Northallerton no exposures are known; the next landmarks are the Rhætic and Keuper exposures before mentioned near Thornborough and Thornton-le-Moor. The road leading into the latter village from Borrowby is formed of red marls nearly to the top.

Blue and red marls with gypsum are seen in an excavation behind the ice-house at Wood End; the uppermost bed is an indurated band similar to that noted near Hill-top.

The next exposure near the junction, that we know of, is at a well near the tan-yard at South Kilvington, showing that the line runs eastwards towards Thirsk. A little to the south of this, however, it must take a sudden bend to the west, as we find Liassic strata at Topcliffe. This outshoot is, no doubt, connected with a great fault, which we mentioned in connexion with the upper limit of the Lias, especially as, very soon after, we find the Keuper again to the east—not indeed *in situ*, but so completely forming the red gravel of the Cundall bank, as to show its close proximity, being probably supported below by some Liassic limestones.

South of this place for a very great distance we know of no exposure except the doubtful one at Easingwold. The junction, no doubt, trends east; but its exact line is indeterminable, owing to the vast accumulations of Boulder-clay and warp. It is not till we reach the neighbourhood of Barton Hill that this covering disappears and we are enabled to study the solid rocks below.

The exposures of the Keuper then become numerous and, in a certain sense, continuous, and the line of junction with the Lias is determinable to within a few yards.

Passing the Barton-Hill station, the red marls may be well traced along the hill-side on the north of the railway to a little above Clay Hall, but not further, leaving, however, a small tongue of Liassic strata cut through by the railway. On the south side they are exposed everywhere in brook-sides; and a fine section of the upper part, consisting of green and white marls with bands of coarse white sandstone, is seen on the west bank of the Derwent by Howsham Mill; across the river it may be clearly traced along the base of Howsham Wood. Its upper line is by no means at the same level in all these neighbouring places; at Barton cutting it is about 100 feet, at Clay Hall nearly 150, and at Howsham Wood not much above 50 feet above the mean level of the sea. The overlying Lias beds are not horizontal, but rise northwards and slightly westwards to a fault.

The village of Howsham lies on the Keuper, the line of junction running just east of it, and continuing to the south with a nearly easterly course past Leppington Grange, where it is well exposed in the river-banks, to within a quarter of a mile of Acklam Wood, the last seen of it in this direction also being in the side of the stream. The last mile of this, however, is but a tongue exposed by the denudation of the Lias, which again stands out on the Leppington cliffs, and supports the village, the whole valley being red marl, which may be traced all along the base of the hill, and is exposed in some fine sections near the Leppington corn-mill; from here the the line of junction runs south along the base of the Barthorpe bank, after which the Lias again forms an outstanding hill a little to the north of Bugthorpe. This latter village stands entirely upon Keuper, as may be seen in many small exposures. It is surrounded, however, by the Lias like an amphitheatre, that formation capping a hill to the south of it, called Barf Hill. It was from the streams near this village that some of the earliest figured fossils in England

were obtained by Lister. The line of junction is here thrown half a mile eastward by a fault which passes near Garrowby, on the high-road; on the south of this fault, along the side of a stream, many fine sections of the Keuper may be seen, but they do not consist of the uppermost beds; they are hard flaggy sandstones alternating with white and red marls, much tilted and contorted in the neighbourhood of the fault.

We pick up the line of junction thus thrown out, a little to the east of the Garrowby and Bishop-Wilton road, which runs along the base of a low, chalk-capped hill; the base of this hill is the Keuper, and the middle portion Lias. These two formations are strangely mixed in the broken face of the hill, and if anywhere the junction of them is to be actually seen, this is the most favourable place, should a larger landslip than usual expose the undisturbed rocks beneath.

The village of Bishop Wilton lies on the red marl, which may be seen everywhere along the streets and in all the banks; the boundary runs through the site of Archbishop Neville's palace, and then again turns to the south-west; after leaving the village the line runs due south along the base of the cliffy hill, passing Givendale and Grimthorpe. In Grimthorpe Wood the Keuper beds may be well seen, and may be traced onwards to Swineridge Bridge. They are seen again near Ousthorpe Mill, and occur in the wells of Pocklington. South of this town they are thickly covered by gravels, and their only known exposure, till we come near the village of Nunburnholme, is in a brick-yard on the side of the railway, about a mile from Pocklington. The line of junction runs hard by the church of Nunburnholme, the last hill, coming from Burnby, being entirely red marl; from here the same beds may be traced on to Londesborough, where they are well exposed in the stream-side by the avenue leading up from the station; hence, again, they are continuously seen till we reach Market Weighton, where just north of the railway-station they alone were met with in a well-sinking. The western portion of this town lies on the Keuper, the banks and wells exposing it; but the exact line of junction is not well determined. South of this the country is so covered by glacial drift, often of great thickness, that the New Red marl is scarcely ever seen near where the probably highest bed might be. The elevated hill of Holme is Keuper to the top; but between this and the hills of North and South Cliff but little is to be seen. In the excavations near the farm of Bielsbeck, whence interesting remains of mammals (the mammoth, the lion, the bear, *Bos*, the rhinoceros, the red deer, &c.) have been obtained, the red marl is reached at the base, and probably extends still further to the east; but from here to the Humber the base-line of the Lias is more or less hypothetical and must be determined, if at all, by other considerations than direct observation.

We shall now enter upon the description of the various zones of life in the Lias as enumerated on page 16. Our plan will be to give complete sections of the beds of the zone as exhibited in the most

typical locality, and then notice the occurrence of sections or exposures of these beds in other localities, thereby tracing, as far as may be, the range of each zone. The palæontology of each zone will be discussed after its stratigraphical description, and its relations with the zones above and below it exhibited. In so doing we shall give the justification of the zonal division, and make clear how far it can be legitimately carried out. Numerous Entomostraca and Foraminifera have been found in most of the zones which we shall enumerate; but as it is well known that the latter of these, at least, retain their specific identity (so far as the term species can be applied to them) through several formations, and are even identical with living varieties, we cannot include them in the number of species given from each zone as common to two or more, as that would hide the proportion of peculiar species to the number of really variable types which have a greater range than in one zone.

CHAPTER VI.

ZONE OF AMMONITES PLANORBIS.

1. *General Features.*—The beds between the fossiliferous zone of *Ammonites angulatus* above, and the well-marked Rhætic beds below, have for a long time been a difficulty with geologists, owing partly to the paucity of their fossils, and partly to the variation in their lithology. The uppermost portion of them constitute the zone of *Ammonites planorbis* with all authors; but beneath these Mr. Moore would intercalate two others, the Enaliosaurian and the White Lias.

Now, though undoubtedly the lowest beds exposed in Yorkshire agree in character and fossils with the lowest of these, yet as we possess no great depository of reptiles, and the term White Lias has proved a misleading one, we do not here adopt it, but practically agree with Dr. Wright in including all the lower beds, in our district at least, under the zone of *Ammonites planorbis.*

With this understanding, they may be described as consisting of thick beds of fossiliferous clays, interspersed with thin bands of soft limestones (the universally acknowledged *planorbis*-beds), succeeded below by numerous bands of hard oyster-limestones (*Ostrea liassica*) separated by narrow beds of clay, and these followed again by thicker beds of clay, with variable thinner bands of crystalline, or else soft, limestone. The crystalline limestones contain great numbers of *Pleuromyæ* (the *Pleuromya* limestones), or of *Modiola minima* and *Protocardium Philippianum*; but the softer ones contain only indeterminable impressions, and have a white colour.

2. *Typical Sections.*—The typical locality for these beds (described by one of us, Quart. Journ. Geol. Soc. vol. xxviii. p. 132 *et seq.*) is a low escarpment that runs from North Cliff near Market Weighton towards the Humber (fig. 1, p. 41). Here the beds have a dip to the east and agentle anticlinal also in the same direction; they are cut into by numerous pits for the marling of the adjacent sandy lands, and thus afford very good sections and opportunities of collecting fossils. The most complete of these is contained in a long narrow excavation close to the village of North Cliff: it is as follows :—

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Surface soil	2 3	*Ammonites Johnstoni*, *Cardinia Listeri*, *Ostrea liassica*, *Lima gigantea*.
	Rubbly stone	1 6	
	Rough rubbly clay	1 4	
	Rubbly stone	0 8	
	Probable base of *angulatus*-beds.	3 2	
1.	Rough yellow clay	3 2	*Pentacrinites*.
2.	Stone, with many broken shells.	0 8	
3.	Clay, with many broken shells.	1 0	
4.	Stone, with many broken shells.	1 4	Wood.
5.	Bluer clay	2 2	
6.	Double sandy stone	0 8	*Lima gigantea*, *Modiola minima*.
7.	Blue clay	2 0	*Am. Johnstoni*, *Ost. liassica*, *O. irregularis*, *Avicula inæquivalvis*.
8.	Sandy broken stone	3 7	Oysters.
9.	Blue clay	5 6	*Protocardium Philippianum*, *Ostrea liassica*.
10.	Stone	0 5	*Lima gigantea*.
11.	Blue clay	3 7	*Cidaris Edwardsii*, *Dapedius* (tooth).
12.	Stone	0 10	*Modiola minima*.
13.	Clay with scattered septarian nodules.	2 0	*Am. Johnstoni*, *Hybodus minor*.
14.	Stone	0 5	
15.	Blue clay with few fossils	9 0	*Am. planorbis* (compressed), *Protocardium Philippianum*, *Ichthyosaurus*, sp. (vertebra).
16.	Rubbly soft stone	0 4	
17.	Rough yellow clay	0 4	
18.	Rubbly stone	0 4	
19.	Rough clay	0 5	
	Base of the first section.	37 0	
20.	Double oyster-band	0 6	*Ostrea liassica*, *Protocardium Philippianum*, *Macrodon hettangiensis*, *Nautilus striatus*.
21.	Clay	0 2	
22.	Broken-oyster band	0 5	
23.	Clay, lightest at the top	0 8	*Ostrea liassica*, *Monotis fallax*.
24.	Rubbly stone	0 2	
	Base of the oyster-beds	1 11	
25.	Clay	0 10	
26.	Light sandy rubbly clay	0 4	*Pleuromya crowcombeia*, *Modiola minima*, *Protocardium Philippianum*.
27.	Clay with irregular bands of limestone (*Pleuromya* limestone).	1 6	
28.	Light sandy clay	2 6	
29.	Clay	2 4	
30.	Soft white stone	0 3	
31.	Clay	1 8	
32.	Soft white stone	0 3	
33.	Variable clay	0 6	
34.	Blue clay	3 4	
35.	Whitish sandy stone	0 2	
36.	Clay to the base	2 0	

In this section we see with great clearness the relations of the oyster-bands and the *Pleuromya* limestones to the beds above; but the latter are not largely developed here. In another pit, 1¾ mile further south, these same limestones occur again, as shown in the following section:—

No.	Lithology.	Thickness. ft. in.	Fossils.
1.	Clay....................................	2 6	
2.	Stone band (the equivalent of No. 22 in the last section).	0 3	*Ostrea liassica*
3.	Clay with a variable stone band.	2 6	
4.	*Pleuromya* limestone (=No. 27 in last).	0 4	*Pleuromya crowcombeia*, *Ostrea liassica*.
5.	Clay....................................	0 9	
6.	Double soft sandy limestone ...	0 4	(? insects).
7.	Clay.	1 0	
8.	*Pleuromya* limestone (=No. 30 in last).	0 5	*Pleuromya crowcombeia*, *Modiola minima*.
9.	Clay....................................	1 3	
10.	Narrow band of *Pleuromya* limestone.	0 2	*Pleuromya crowcombeia*, *Modiola minima*.
11.	Clay with variable hard bands.	2 3	
12.	Sandy *Pleuromya* limestone, weathering white.	0 5	*Pleuromya crowcombeia*, *Modiola minima*.
13.	Blue clay.............................	6 0	
14.	*Pleuromya* limestone...............	0 4	
15.	Blue clay.............................	10 0	

Here we have these limestones fully developed: the intermediate clay beds are much broken up by thin bands of soft stone; but the whole series well illustrates the lithological characters of the White Lias, or the insect-limestones of the S. of England. In a pit still further south, close by the crossing of the road to Hotham, another good section may occasionally be seen, in which we may trace each bed with its corresponding one in the section above. In this pit, however, the limestones have become much stronger. No. 4 has become ten inches thick, and No. 8 six inches thick. In the last pit *Pleuromya crowcombeia* was chiefly associated with *Modiola minima*; in this the limestones contain numerous oysters, and we may even say that there are oyster-layers lying *below* the *Pleuromya* limestones. In the clays, however, which lie at the base of this quarry the *only* impressions found are those of *Pleuromyæ*; so that nowhere here do we get below the horizon of this shell.

The clays *above* the oyster-bands in these exposures of the *planorbis*-beds are remarkable for the abundance of their Foraminifera, having afforded us a very varied gathering; but with the oysters they cease as we trace the beds downwards, and with them the accompanying Entomostraca.

In tracing the range of this zone across the country, our guides are the oyster bands and the *Pleuromya* limestones, no other portion of the series being sufficiently marked for identification. If we compare the sections above given with the fact before stated, of the oc-

currence of these limestones about 25 or 30 ft. above the shales with *Cassianella contorta*, in the neighbourhood of Northallerton, we have a pretty fair idea of the true sequence of the beds, and seem to learn that we have not far to go below the lowest beds at Cliff to reach the horizon of the true Rhætic.

3. *Other Exposures of the* planorbis-*zone.*

I. Southern Area.

1. In the first cutting of the railway from Market Weighton to Beverley, close by the bridge leading from Goodmanham, the lower beds of the Lias are well exposed, dipping to the N.E. They chiefly consist of clay: but at the base occur bands of oysters; and at the top, limestones with *Lima gigantea* and *Ammonites Johnstoni.*

2. Beds of this age crop out from beneath the Chalk in Londesborough Park. They may be well seen on the east side of the valley, forming the banks which overhang the ornamental water. This water is derived from copious springs coming from beneath the Chalk, which here overlaps this zone of the Lias. A still better section may be seen close beneath Park Farm on the other side of the valley; here the waters of a spring, passing over the Lias, expose the various courses of hard blue limestone and interstratified clays which represent the zone.

3. On tracing up the stream that leads from Nunburnholme to Warter we meet with several indications of the lower part of the Lias; about a quarter of a mile up we see the oyster-beds; half a mile further on, the blue clays and limestone bands of the upper part of this zone; and about half a mile from Warter, an excavation with the fossiliferous beds to the *angulatus*-zone.

4. The bold hill which protects Pocklington on the N. and E. is based upon beds of this zone, which may be well traced in the side of the lane leading up it from the town. Here

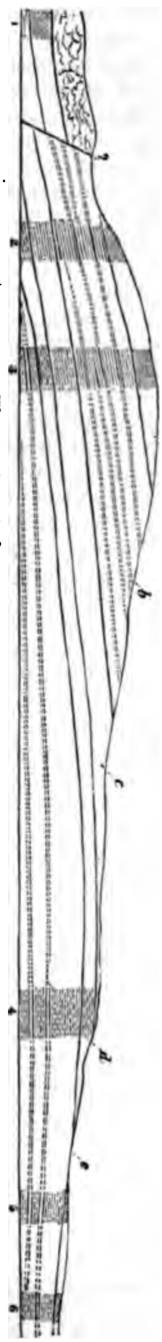


Fig. 1.—*Diagram Section of Infraliassic Beds, near Cliff, Yorkshire.*

The numbers 1, 2, 3, 4, 5, 6 indicate the pits referred to.

a. Zone of Am. angulatus.
b. Am. Johnstoni only. } Zone of *Am. planorbis.*
c. Am. planorbis.

d. Oyster-bands.
e. Clays with white limestones. } White Lias.

are exposed the intervening clay beds and the blue limestones, and, at the very base, the oyster-beds; while from above are washed down small fragments of the fossiliferous *angulatus*-beds. The succession of these may also be traced all round this escarpment in Pocklington Wood, but not so clearly.

5. At Swineridge Bridge on the Givendal road, black shales have been dug up for the purpose of brick-making, but were found unsuitable, the spoil-heaps have unfortunately yielded no fossils to a careful search; they might well belong to the zone of *Cassianella contorta*; but if not, they at least lie towards the base of that of *A. planorbis*.

6. In its continuation, the escarpment of the Lias becomes very bold near Grimthorpe; the broken ground looking S.W. exhibits numerous blocks of limestone belonging to the upper part of the zone.

7. In the fields to the right of the road leading from Bishop Wilton to Garrowby, numerous fragments of the *Pleuromya* limestones are scattered about; and a little further on, we come to a scene of great landslips, in which these and the Keuper marls are inextricably confused.

8. On the north of the fault which here pushes the Lias eastwards, we find at Barf Hill, near Bugthorpe, numerous fragments of *Pleuromya* limestone, obviously not far removed from their place.

9. We have already mentioned, in connexion with the Rhætic, the occurrence of *Pleuromya* limestones in Bugthorpe Beck.

10. For some distance no very clear signs of the Lias appear, till we come to within a mile of Leavening, when in Moor Beck, just north of Acklam Wood, there is a fine section of these beds dipping rapidly (12° to 14°) to the N. from a fault running E. to W. which passes near this spot. Here the *Pleuromya* limestones are of considerable thickness, and the finest specimens of the fossil may be collected.

11. If we cross over the hill to the north, and follow the stream which runs in the next valley downwards, we shall find on its sides several exposures of shales, the fossils of which are scarcely to be determined but from their position, and by analogy seem to belong to this zone.

12. In the second cutting of the N.E. Railway, north of Barton-Hill station, some Lower Lias beds are exposed. They appear to dip about 3° to the E.N.E. The upper beds belong to the zone of *Am. angulatus*; but the lower ones consist of the blue clays and limestones of the upper part of the *planorbis*-zone.

13. On a small hill to the east of Raskelf, many fragments of *Pleuromya* limestone may be picked up; but as they occur with many other kinds of stone, there is little to show whence they came.

II. Northern Area.

1. The non-Ammoniferous portions of the zone of *Ammonites planorbis* are well exposed in the Northallerton district, and most especially in Dibdale, as already mentioned in connexion with the Rhætic beds.

Here, some 25 or 30 feet above the *Cassianella-contorta* shales, are

two thin bands of *Pleuromya* limestone amongst rotten shale; these appear to have a slight dip to the S.E. Following up the stream, which is nearly on the line of strike, we encounter, 25 feet higher, black paper shales, which appear, at intervals, still higher; and near to its source are some thin blue subcrystalline limestones with *Ostrea liassica* and *Hemipedina*, sp., the position of these last being about 50 feet above the Rhætic shales.

The *Pleuromya* limestone is a lumachelle; but the species are few in number: the chief are *Pleuromya crowcombeia, Ceromya infraliassica, Protocardium Philippianum, Ostrea liassica, Macrodon hettangiensis*, and *Modiola minima*. *Actæonina fragilis* and *Pleurotomaria concava* (?) also occur. It is crowded with *Bairdia liassica*, which imparts an oolitic appearance to the stone.

2. At Hallikeld Farm the upper part of the stream-course displays shales with thin bands of earthy and subcrystalline limestones, the lower limestones containing *Pleuromyæ*—and the higher, oysters.

3. Similar shales and thin *Pleuromya* limestones occupy a low brow skirting the north side of the stream at Foxton, and also form the ground around that hamlet. The fossils in the limestone are identical with those of the same limestones obtained near Northallerton.

This exposure is the most northern known to us; but beds on the same horizon have been brought to light in two pits:—one the Eston gypsum-pit; and the other at Coatham, in the extreme north of the Riding.

4. Eston gypsum-pit. Among the materials of the spoil-heap at this pit we have observed:—

(*a*) Brown shelly limestone, chiefly made up of the shells of *Pleuromya crowcombeia* and *Protocardium Philippianum*, and also yielding *Ostrea liassica, Macrodon hettangiensis, Modiola minima, Astarte obsoleta*, and *Hemipedina Tomesii*. Our inability to fix the position of this limestone (thought by Mr. G. Lee to be 100 feet down), so easily recognized, is most unfortunate, as it is encountered in so many sections, in not one of which can we speak with confidence of its exact stratigraphical relation to the shales with *Cassianella contorta*.

(*b*) Black shales containing *Ammonites planorbis* and *Cidaris Edwardsi*.

(*c*) A fissile calciferous sandstone, containing *Protocardium Philippianum* and *Modiola minima*. This may belong to the set of beds No. 19 in the section p. 31.

5. Coatham pit. Mr. Peacock (*loc. cit.* 1870) has recorded that "about 13 years ago, a six-feet pit was sunk to a depth of 32 fathoms on the marshes near Coatham by the late Mr. Slater, with the object of finding a seam of coal." This pit is situated between two ponds in the second field which is crossed by the foot-path to West Coatham on leaving the Kirkleatham road. On the spoil-heap no Keuper marls are to be seen; but the presence of thin flaggy sandstones is rather indicative of the horizon of *Cassianella contorta*. A dark-coloured

are exposed the intervening clay beds and the blue lir ... at the very base, the oyster-beds; while from abov ... down small fragments of the fossiliferous *angulatus*-l ... cession of these may also be traced all round thi ... also a Pocklington Wood, but not so clearly. ... a dark

5. At Swineridge Bridge on the Givendal road. ... containing been dug up for the purpose of brick-making, but ... block of able, the spoil-heaps have unfortunately yielded ... *Cerithium* ful search: they might well belong to the zon ... (small ex-*torta*; but if not, they at least lie towards th ... *lævis*, *Pinna* *planorbis*. ... and *Hemipe-*

6. In its continuation, the escarpment o ... bold near Grimthorpe; the broken ground ... ntained *Car-* merous blocks of limestone belonging to th ... *A. obsoleta*,

7. In the fields to the right of the road ... *nella plicatis-* ton to Garrowby, numerous fragments of ... are scattered about; and a little furth ... similar to one oc-great landslips, in which these and the K ... are the same; but confused. ... *A. Johnstoni* and

8. On the north of the fault which h ... facies of the fauna we find at Barf Hill, near Bugthorpe, ... and not of *A. pla-* ... limestone, obviously not far re ...

9. We have already mentioned, in ... limestone have occurrence of *Pleuromya* limestone ... in some in-

10. For some distance no very ... apparently iden-we come to within a mile of Lea ... name of *erugatus*, north of Acklam Wood, there is ... fossils of the *angu-* rapidly (12° to 14°) to the N. f ... *Macrodon het-* passes near this spot. Here ... more remarkable is siderable thickness, and the ... *planorbis* in the collected. ... position of either of

11. If we cross over the ... among the fossils of the which runs in the next val ... present undecided. If several exposures of ... beds below with *A. pla-* determined but from ... we should say that this zone. ... -beds; if low down,

12. In the second ... *planorbis*-zone altogether, Hill station, some ... and using another name about 3° to the E.N. ... It is possible that *angulatus*; but ... different species; but of stones of the ...

13. On a small ... *Pleuromya* limestone ... other kinds of ...

... A. PLANORBIS.

1. The ... the zone of *Ammonites pla-* *norbis* are w ... characteristic; and it is pecially in ... overlying zone that it is Rhætic bed ... of the *Cassianella-con-* ... majority of species common Here, son ... *angulatus*. A remarkable

CHAPTER VII.

ZONE OF AMMONITES ANGULATUS.

This zone, though established by Oppel and accepted on the Continent, was not adopted by Dr. Wright, on the ground of its insufficient distinctness from the *Bucklandi*-beds, though one of us has shown it to be well developed at many localities in England and Ireland. Although many of the fossils of the two series are the same, yet we find no difficulty in, but rather necessity for, separating them, as they contain among the rarer kinds many that are peculiar to each, and those more ordinarily occurring are by no means identical.

In the southern area these beds consist of thin rubbly limestones of a yellow colour, sometimes, however, thicker and darker, sometimes almost crystalline, but more often soft and earthy, and occasionally ironshot. In many cases the greater part of the stone is made up of comminuted fossils, the beds generally being highly fossiliferous.

This stone is known, in the country, when broken by the weather, under the name of "grey stone," which is also applied to the beds of the Inferior Oolite south of Market Weighton. It is by the occurrence of such pieces of fossiliferous stone that we are enabled to trace it across the country, especially as distinguished from the *planorbis* limestones, which, except the peculiar ones at the base, are not often fossiliferous.

No very complete section of the *angulatus*-zone is anywhere to be seen; but in a pit three miles from Market Weighton, on the Cliff road, we get the best developement of their lower part, passing downwards to the *planorbis*-zone; and at Redcar we get the upper part, showing its passage into the *Bucklandi*-zone.

The section in the pit near Cliff, is as follows:—

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Zone of *Am. angulatus*.		
1.	Sandy clay	3 0	
2.	Rubbly limestone	0 6	Very fossiliferous when weathered, *Am. angulatus*.
	Sandy clay	1 0	
3.	Rubbly limestone	0 10	*Am. angulatus*.
4.			
	Zone of *Am. planorbis*.		
5.	Clay, sandy at the top, gradually becoming less so.	8 0	

Beds No. 2 and 4, here, have yielded a great variety of fossils associated with *Ammonites angulatus*, and in fact give the best fauna of that zone; the list is too long to record in connexion with the section, especially as the great majority of the fossils were obtained from the heaps of these stones at the quarry-side. The clay of bed No 5 we reckon with the zone of *Ammonites planorbis*. Neither Foraminifera nor other fossils occur in beds No. 1 and 3, though the *angulatus*-beds are not without Foraminifera at Redcar.

Another pit nearer to North Cliff, though not showing so much of the *angulatus* series, yet exhibits better its relations to the *planorbis*-zone below; in it we have:—

No.	Lithology.	Thickness. ft.	in.	Fossils.
1.	Rubbly limestone	1	10	*Nautilus striatus*, *Pleurotomaria obesula*.
2.	Yellow sandy clay	2	0	*Lima gigantea* &c.
3.	Rubbly limestone	1	9	*Ostrea ungula*.
4.	Blue clay, with gypsum	5	4	*Lima gigantea*, *Am. Johnstoni* (common).
5.	Limestone		6	
6.	Blue clay	3	3	
7.	Irregular course of septarian nodules.			
8.	Blue clay	3	0	

and so on into the *planorbis*-series, the section being similar to the typical one of that zone. Here the three upper beds belong to the *angulatus*-series, and they have yielded some of the characteristic fossils, and they are continued, as before mentioned, into the topofthe *planorbis*-pit.

In these sections we see the beds graduating into those beneath them; and we will now give the section at Redcar, which shows their passage upwards into the *Bucklandi*-beds.

As already indicated, there is good evidence of the development in this neighbourhood of a considerable thickness of Liassic strata below the beds containing *Ammonites angulatus*, the lower portion of which invariably contains *Ammonites Johnstoni*. It is at the top of this portion that the Redcar section begins. At certain times there have been exposed at the low-water mark of spring tides, opposite the Battery, beds of blue shale, which have been traced many yards to the east. These belong to the zone of *Ammonites Bucklandi*; but by a fault, which courses at nearly right angles to the shore, a thick limestone with *Ammonites Johnstoni* is brought to view. This limestone also forms the mass of the island of Leigh-Dam Scar, immediately opposite. The beds have a general dip to the N.W., but are at first irregular; and though the section is fragmentary in parts, yet there is traceable a nearly regular succession of shales with limestone nodules, and layers of shells and shelly débris, till the scars called the East Flashes are reached, where the *Bucklandi*-series is commenced. The mineral condition of these beds is very different from that which

generally prevails, being essentially argillaceous, or with a very limited amount of calcareous matter widely diffused in the shales.

The strata occupy a breadth of 385 yards, of which 411 feet afford a continuous section, with a dip increasing from 4 to 6 degrees, and represent a vertical thickness of 36 feet; and the whole is estimated at 50 feet.

The series is as follows, in which the leading palæontological features are incorporated.

Section of the angulatus-*beds, Redcar.*

No.	Lithology.	Thickness. ft. in.	Organic Remains.
102.	Base of lowest scar of the *Bucklandi*-zone: for continuation see *post*.		*Ammonites Conybeari, Lima gigantea, Pentacrinus.*
103.	Blue shale with a line of *Am. Conybeari* at a depth of 1 foot.	2 8	*Cardinia Listeri, Gryphæa arcuata, Lucina limbata, Pentacrinus.*
104.	Indurated shale 5 inches, earthy limestone 1 inch.	2 6	*Am. angulatus* and small *Gryphæa, Unicardium cardioides.*
105.	Blue shale		*Am. angulatus.*
106.	Friable shale, an oyster-band and irregular limestone nodules, 1½ inch.	0 7	*Am. angulatus, Pleurotomaria similis, Dentalium etalense, Astarte Oppeli, Lima gigantea, Cardinia Listeri, Pleuromya crassa, Serpula socialis, &c.*
107.	Blue shale	1 0	Large *Am. angulatus* and scattered *Gryphæa.*
108.	Friable shale, with oysters chiefly (2 inches).	0 5	*Am. angulatus, Cardita Heberti, Lucina limbata, Plicatula liasina, Terquemia arietis, Perna infraliassica, Rhynchonella plicatissima, Montlivaltia polymorpha.*
109.	Blue shale		
110.	Band of small *Gryphæa* ½ inch.	3 0	*Am. angulatus, Plicatula liasina.*
111.	Blue shale		
112.	Shell band and shelly limestone, 1½ inch. Blue shale with irregular doggers, 5 inches.	6 4	*Am. angulatus, Eucyclus elegans, Astarte obsoleta.*
113.	Blue shale		*Am. angulatus, Eucyclus acuminatus.*
114.	Shelly limestones, sometimes encrinital, mixed with shale, 2½ inches.	2 8	
115.	Blue shale		
116.	"Coral bed," a friable shale with small pebble-like concretions at the top, very fossiliferous, 2½ inches.	2 0	*Am. angulatus, Astarte Oppeli, Cardita Heberti, Plicatula liasina, Pleurotomaria similis, Montlivaltia Haimei, Serpula socialis, Waldheimia sarthacensis, &c.*

No.	Lithology.	Thickness.	Organic Remains.
		ft. in.	
117.	Depressed irregular limestone doggers, 1½ inch.		
118.	Shale with scattered *Gryphæa arcuata* of moderate size.		*Am. angulatus* (large).
119.	Earthy subcrystalline limestone, 1 inch.	1 2	Large *Am. angulatus*.
120.	Black smooth shale		
121.	Friable shale .... / Oyster-band	0 6	
122.	Smooth shale	0 6	
123.	Siliceous limestone, ½ inch.........		
124.	Smooth shale		
125.	Irregular depressed limestone doggers. / Thin shell-limestone	3 2	*Lima gigantea* of large size.
126.	Friable shale .... / Smooth shale, 9 inches		*Am. angulatus*, very large.
127.	Earthy limestone or doggers ...	0 2	*Cardinia ovalis*.
128.	Smooth shale	1 0	
129.	Blue siliceous limestone...........	0 1	*Ostrea ungula*, *Dentalium etalense*.
130.	Friable shale, *Am. angulatus* ...	0 8	These beds, which occupy a breadth of 14 feet, are somewhat disturbed, perhaps by a fault, but have a decided dip to the north-west.
131.	Siliceous limestone or, rather, a band of depressed doggers fused together.	0 2	
132.	Friable shale, *Am. angulatus* ...	1 5	
		30 0	
133.	Friable shale	3 0	Occupy a breadth of 47 feet; but from the low dip to the north-west the whole may not exceed 3 feet in thickness.
134.	Oyster-band, 1 inch		
135.	Depressed limestone doggers ...		
136.	Blue shales		
137.	Siliceous limestone, ½ inch........		
	Interval of 270 yards covered with Boulder-clay.		
	Very hard grey subcrystalline limestone, mottled with white calcite.	0 8	Is very much disturbed and curved sharply down to the fault, carrying with it a friable shale, 3 inches, full of *Cardinia ovalis*, which is not elsewhere seen on the shore.

The *Cardinia* shales contain *Am. angulatus* (a thick-ribbed variety), *Astarte cingulata*, *Nucula navis*, *Lima gigantea*, *Macrodon hettangiensis*, *Modiola lævis*, *Hemipedina Tomesii*; the limestone, *Ammonites Johnstoni*, *Am. angulatus*, *Cardinia ovalis*, *Lima gigantea*, *L. pectinoides*, *Pecten textilis*, *Cidaris Edwardsi*, *Nautilus striatus*.

Leigh-Dam Scar consists of:—

1. Bluish compact limestone. 2. Calcareous shale. 3. Earthy limestone. 4. Calcareous shale.	The whole about 3 feet, 1½ foot of which rises above the level of the lowest spring tides.

The fossils are *Ammonites Johnstoni, Cardinia ovalis, Pecten calvus, Lima gigantea, L. pectinoides, Gryphæa arcuata, Waldheimia sarthacensis.*

Other Exposures of the angulatus-*beds.*—In the northern area no other exposures of the *angulatus*-beds are known; but they have been proved to exist over the low plain stretching from Redcar towards Eston. We have already referred to the association of *angulatus*-fossils and *Ammonites Johnstoni* with *A. planorbis* in the Coatham pit. The limestone in which they occur has some resemblance to that of Leigh-Dam Scar; but in the Eston gypsum-pit more decided analogies are exhibited, especially bed No 10 of that section, an earthy limestone comparable with one in the Coatham pit, and containing the same general assemblage of fossils, viz. *Ammonites Johnstoni, A. angulatus, Nautilus striatus, Dentalium etalense, Cerithium tenuicostatum, Cardinia ovalis, C. Listeri, Modiola hillanoides, Astarte obsoleta, Macrodon hettangiensis, Hippopodium ponderosum* (juv.), *Lima hettangiensis, L. punctata, L. pectinoides, Unicardium cardioides, Gryphæa arcuata, Cidaris Edwardsi, Hemipedina Tomesii* and *Pentacrinus psilonoti.*

A well sunk for the houses on West-Coatham Marsh passed through about 10 feet of reconstructed Boulder-clay into friable blue shales with lines of irregular nodules to a depth of 32 feet. The fossils were the common species in the *angulatus*-beds at Redcar.

There is no proof that any portion of the *Bucklandi*-zone was passed through in the Eston pit; and as the mineral characters of the upper beds are represented by the *angulatus*-beds at Redcar, we are induced to regard this section as representing the full thickness of the *angulatus*-beds to the Rhætic inclusive, being 154 feet, 14½ of which belongs to the latter. This thickness may be distributed as follows:—

	ft.	in.	
Upper *angulatus*-beds..................	36	0	measured at Redcar.
Lower *angulatus*- and *planorbis*-beds	*53	8	
Oyster- and *Pleuromya*-beds	*50 ·	0	at Northallerton.
Rhætic series	14	5	as actually determined.
	154	1	

The only exposure of this zone known to us in the middle region of the county, *i. e.* for many miles on either side of Thirsk, is a very interesting one in the bank of the river Swale, opposite Topcliffe, to the right of the road leading from Asenby. Covered by a great thickness of red sand and gravel at the base of a considerable cliff, appear rough dark-blue sandy shales with bands of harder rock of a similar character; at a lower level calcareous bands occur in the side of the stream. Their dip is not uniform or considerable; on the whole

* These thicknesses are not excessive, inasmuch as the single section of North Cliff gives a total of 64 ft. 2 in. for the *planorbis*-beds and a portion of the *pleuromya*-beds only, whilst for another section not reaching to the Rhætic an addition of 15 feet must be made.

it is perhaps E.S.E. These beds only peep out, here and there, from beneath their sandy covering, and are not very fossiliferous, except as containing patches of comminuted shells. We have, however, collected *Gryphæa arcuata*, *Lima gigantea*, *Lima hettangiensis*, *Lima pectinoides*, *Cardinia ovalis*, and *Cardinia Listeri*, which leave us in some doubt as to whether they belong here or to the *Bucklandi*-beds. The interest attaching to this section is, that it lies far to the west of the general line of junction of the Lias and Keuper, and proves the former to run out as in a tongue; and beds higher in the series are now known to do the same.

Fragments of stone have been picked up near Thirkleby containing *Astarte obsoleta* and *Phasianella morencyana*.

We have already mentioned the cutting near Barton-Hill station, the upper part of which reaches the *angulatus*-beds, as shown by the commonness of *Cardinia ovalis* with *Lima gigantea*.

Fragments of "grey stone" may be seen in Leppington Beck, further up than the sections of Keuper, and also in a tributary to Gilder Beck beneath Hanging Grimston.

At Kirby Underdale, in the road leading down past the church to cross a little stream, Lower Liassic beds are seen in *situ*; the uppermost belong to the *Bucklandi*-zone, and the lower, near the stream, to that of *Am. angulatus*.

In Garrowby Beck, close by the turnpike road, on the south side of which are the Keuper marls, the lower beds of the Lias may be traced in numerous fragments and occasional patches of rock in *situ*, all dipping slightly to the N.E. Nearest to the road the fragments belong to the zone under consideration, *i. e.* are without numerous *Gryphæa arcuata*, and contain *Am. angulatus*; further up they belong to the *Bucklandi*-series and show several oyster-beds in *situ*: a good series of fossils might be obtained here; *Cardinia Listeri* is very common.

Further along the same road, on the left as you begin to ascend the hill, is a field whose every fragment is "grey stone" containing innumerable broken fossils.

On the side of the valley to the left hand of the road leading from Givendale to Pocklington, just before reaching Swineridge Bridge, quarries have been opened for road-stone. The rocks thence extracted are of this age; and the blocks left in heaps to weather have yielded many fossils—in fact, after Cliff and Redcar, have been a main source of them. The beds here are more crystalline and thicker than we have seen elsewhere, and form excellent road-metal; but no good section is visible; they belong, however, to the lowest part, and have the *planorbis*-clays below. Fossils from these blocks we have labelled "Millington," the nearest village.

The exposure near Warter has been already mentioned in connexion with the *planorbis*-beds.

All the way along beneath the chalk escarpment which bulges out between Londesborough and Goodmanham, fragments of "grey stone" full of broken fossils, which are sometimes sufficiently preserved for identification, are scattered plentifully over the fields,

though no good exposure takes place; they may be seen in *situ*, however, in three springs which enter from the west into the beck that comes down to the west of Goodmanham from the chalk hills, the highest of the springs being by the road-side; they may also be seen on the road from Market Weighton to Goodmanham, in the ditches.

Very near the last-mentioned exposures are those to be seen along the side of Mill Beck, which are the continuation of the beds before mentioned as capping the railway-cutting near Market Weighton, and which dip downwards at 2½° to the east. They include the upper beds of the series, as we find in the same stones, but not as yet in one block, *Am. angulatus* and *Belemnites infundibulum*.

PALÆONTOLOGY.

The zone of *Ammonites angulatus* is exceedingly rich in organic remains and contains many peculiar forms, among which may be enumerated *Ammonites angulatus*, *Pleurotomaria obesula*, *Eucyclus acuminatus*, *Lima hettangiensis*, *L. Terquemi*, *Anomia striatula*, *Cardinia ovalis*, *Astarte Oppeli*, *Septastræa excavata*, *Montlivaltia polymorpha*, and others of less certainty or consequence.

A few of its commoner fossils began existence before the rest, and are found in the *planorbis*-zone; such are *Ammonites Johnstoni*, *Nautilus striatus*, *Lima gigantea*, *Macrodon hettangiensis*, *Astarte obsoleta*. If we were to consider the fragments obtained on the coast and at Coatham containing *Am. planorbis* as belonging to this zone, we should have to add that Ammonite to this list.

More of the fossils pass upwards to the *Bucklandi*-beds, but by no means sufficient to make us unite the two zones; whilst the frequency of occurrence of many of the recurrent species in the two zones is in great contrast, as will be detailed at the close of the following chapter.

The total number of species belonging to this horizon is 117, not including the Foraminifera.

List of Fossils from the angulatus-*beds.*

Ichthyosaurus (vertebra).
Plesiosaurus (tooth).
Hybodus minor.
Acrodus minimus.
Ammonites angulatus.
—— Conybeari.
—— Johnstoni.
— longipontinus.
—— nanus.
Nautilus striatus.
Belemnites infundibulum.
Discohelix striata.
—— semiclausa.
Pleurotomaria obesula.
—— similis.
—— tectaria.
Pitonellus sordidus.
Cryptænia solarioides.
—— rotellæformis.
—— nucleus.
Phasianella Morencyana.
Turbo solarium.
—— philemon.
Littorina semiornata.
Eucyclus elegans.
—— acuminatus.
Turritella Dunkeri.
Chemnitzia transversa.
—— Berthaudi.
—— unicingulata.
—— etalense.
Cerithium gratum.
—— semele
—— spiratum.
Dentalium etalense.
—— limatulum.
Actæonina fragilis.
Ostrea ungula.
—— semiplicata.
—— (Gryphæa) arcuata.

Anomia alpina.
—— striatula.
Plicatula liasina.
Pecten calvus.
—— punctatissimus.
—— textilis.
—— textorius.
Lima gigantea.
—— hettangiensis.
—— pectinoides.
—— punctata.
—— succincta.
—— Terquemi.
Limea Blakeana.
Avicula Pattersoni.
Perna infraliassica.
Pinna Hartmanni.
Macrodon pullus.
—— hettangiensis.
—— navicula.
Leda galathea.
—— Renevieri.
—— texturata.
—— v-scripta.
Nucula navis.
Astarte obsoleta.
—— cingulata.
—— Oppeli.
Hippopodium ponderosum.
Cardita Heberti.
Protocardium Philippianum.
Cardinia crassiuscula.
—— ovalis.
—— Deshayesii.
—— Desoudini.
—— Listeri.
Lucina limbata.
Modiola hillanoides.
—— lævis.
Modiola Hillana.
Saxicava arenicola.
Myoconcha psilonoti.
—— inclusa.
Unicarduim cardioides.
Pholadomya glabra.
Gresslya galathea.
Pleuromya crassa.
Ceromya gibbosa.
Waldheimia sarthacensis.
Rhynchonella plicatissima.
Spiriferina rostrata.
Bairdia liassica.
—— lacryma.
—— redcarensis.
—— elongata.
Cythere Blakei.
—— circumscripta.
—— paupercula.
—— redcarensis.
—— arcæformis.
Polycope cerasia.
Ditrypa capitata.
—— globiceps.
Serpula limax.
—— plicatilis.
—— flaccida.
Galeolaria socialis.
Holothuria, sp. ?
Cidaris Edwardsi.
Hemipedina Tomesii.
Pentacrinus psilonoti.
—— basaltiformis.
Septastræa excavata.
Montlivaltia Haimei.
—— polymorpha.
Conifer.
Pecopteris (fragment of pinnule with sori).

CHAPTER VIII.

ZONE OF AMMONITES BUCKLANDI.

That portion of the Lower Lias which is best known on the Yorkshire coast, and which has been referred by previous authors to the base of the formation, is the series characterized by the presence of the sulcated or arietian Ammonites, of which *A. Bucklandi*, *A. bisulcatus*, *A. Conybeari* and *A. Turneri* are widespread and well known examples. This group of strata is constituted, in the midland and south-western counties of England, of moderately thick-bedded blue hydraulic limestones, designated as " blue lias " or " *Lima*-beds;" but in Yorkshire it is a great argillaceous series, consisting chiefly of shales with shelly tops and thin earthy and shelly limestones—characteristics which are presented by the Scottish strata on the same horizon, and in a modified degree by the underlying beds of the zone of *Ammonites angulatus* in Cleveland.

The *Bucklandi*-beds also, which are worked for iron-stone at Frodingham, in Lincolnshire, have more relationship to the Yorkshire series than to the " Blue Lias," consisting of thin rubbly limestones interstratified with thicker bands of clay, and resembling more closely the southern than the northern series of Yorkshire *Bucklandi*-beds.

It is from the prevalence in these strata of *Ammonites Bucklandi* that they have been called the " *Bucklandi*-beds," as from the abundance of *Lima gigantea* the " *Lima*-beds."

It is this part of the Lias that is the home of the true form of *Ostrea* or *Gryphæa arcuata*; oyster-bands of this species are common in the zone (hence called the Gryphite-beds or Limestones), as those of *O. liassica* are in the *planorbis*-beds; and it is thus to this zone that most of the foreign fossils said to occur with *Gryphæa arcuata* belong.

Some other species of *Ammonites* are abundant in these beds; but, having a more restricted vertical range, they serve to particularize regions within the zone; thus *A. Conybearei* is confined to the base, *A. Charmassei* to the lower half, *A. Sauzeanus* to the upper part, and *A. semicostatus* and *A. Turneri* to the top. Oppel made the region of *A. Turneri* a zone of the Lower Lias; but as we cannot find any peculiarities of organic life, and as the species associated with this Ammonite are common forms in his zone of *A. Bucklandi*, we prefer to include it within the latter. Indeed if there be a distinctive feature at all, it is that of a paucity of species.

The most complete section of the *Bucklandi*-beds in the county is that presented by the Redcar rocks, which are covered by the sea at

high water. They consist of two sets of scars separated by a broad expanse of a level pavement of shale. The scars succeed each other at pretty regular intervals, have the general direction of E. by N. and W. by S., and are formed by the indurated tops of the shales. Owing to the unequal hardness and the considerable dip of the beds, the results of the planing action of the sea have been the production of an appearance suggestive of a deeply ploughed field, in which the ridges are the hard bands in a long succession of parallel lines, and the furrows the yielding shales. Some veins of calcite intersect the beds; and the general symmetry of the whole is somewhat interrupted by many small faults, which usually make a large angle with the line of strike, though there are a few which are nearly parallel to it.

The whole of the Redcar rocks, which are accessible at the lowest tides, with the exception of the *angulatus*-beds beyond the eastern set of scars, are included within the palæontological group of the *Bucklandi*-series. The dip is directed W. of N., and varies in amount, increasing from 6° in the lower part of the beds to 10° or 11° in the upper; the breadth measured in the line of the true dip is 1020 feet, from which data and actual measures the thickness is calculated at 180 feet.

This thickness may be divided into regions upon the basis of lithological and palæontological features. There is first the *Lower Series*, embracing the rocks of the East Flashes and Jenny Leigh's Scar, consisting chiefly of black crumbling shales surmounted by doggers and thin earthy and shell limestones. The breadth of surface occupied by them is about 160 feet, which corresponds with a thickness of 19 feet. There is a considerable variety of fossils, the chief among the more abundant and restricted species being *Ammonites Conybeari, Eucyclus elegans, Rissoa nana, Turbo philemon, Discohelix Oppeli, D. striata, Monotis papyria, Tancredia ovata, Plicatula liasina, Rhynchonella plicatissima, Montlivaltia Haimei, Galeolaria socialis.*

The middle series comprises a considerable thickness of soft blue shales, with rows of small limestone nodules; but towards the upper part it contains some friable shales, and bands of shells. The breadth of outcrop is 530 feet; and the thickness is estimated at 93 feet.

The friable shales are the chief repositories of the fossils, of which there is a fair variety as to species, and which are here in a good state of preservation. The shell-banks are made up of the remains of a limited number of species; and there is a different association in nearly every case. Thus we note one bank of oysters (*O. arcuata*) and corals (*Montlivaltia Guettardi*), another of *Hippopodium ponderosum, Cardinia concinna*, and *Lucina limbata*, a third of *Cardinia Listeri* and *Unicardium cardioides*, and a fourth of oysters only. The shells of these banks are closely packed side by side, constituting a single layer only, and would seem to represent but one generation, the several examples of each species being all of about the same dimensions. In the case of *Cardinia concinna*, in one of the banks

just alluded to, the specimens are all of middle growth, not exceeding 2 to 2¼ inches in length; but situated 2½ inches above in the overlying shales are other examples of the same species, all of which are from 4 to 5 inches in length. The adult forms are comparatively few in number, the smaller ones being abundant; it would thus appear that whilst the majority of the young shells were overwhelmed by the incursion of mud, a few escaped destruction and lived on to an advanced age, and that the rate of deposition of the intervening thickness of shale may therefore be measured by the period of time during which these shells lived from the adolescent to the senile stage of growth.

The soft shales have yielded very few species; but the following are common in them—*Ammonites bisulcatus*, *A. Charmassei*, *Lima gigantea*, and *Pleuromyæ*.

The common species, among the more or less restricted forms, in the Middle *Bucklandi*-beds are *Ammonites bisulcatus*, *A. Charmassei*, *Cryptænia solarioides*, *Turbo solarium*, *Cerithium gratum*, *Turritella Dunkeri*, *Hippopodium ponderosum*, *Unicardium cardioides*, *Cardinia concinna*, *C. crassiuscula*, *Pecten textorius*, *Montlivaltia Guettardi*.

The upper series is chiefly constituted of earthy limestones and calcareous shales, the aggregate thickness of the purely argillaceous beds forming less than the moiety of the whole, which is estimated at 66 feet, as calculated from a breadth of outcrop of 340 feet. The hard beds of this series form the East Scar and a few of the narrow scars seaward of it.

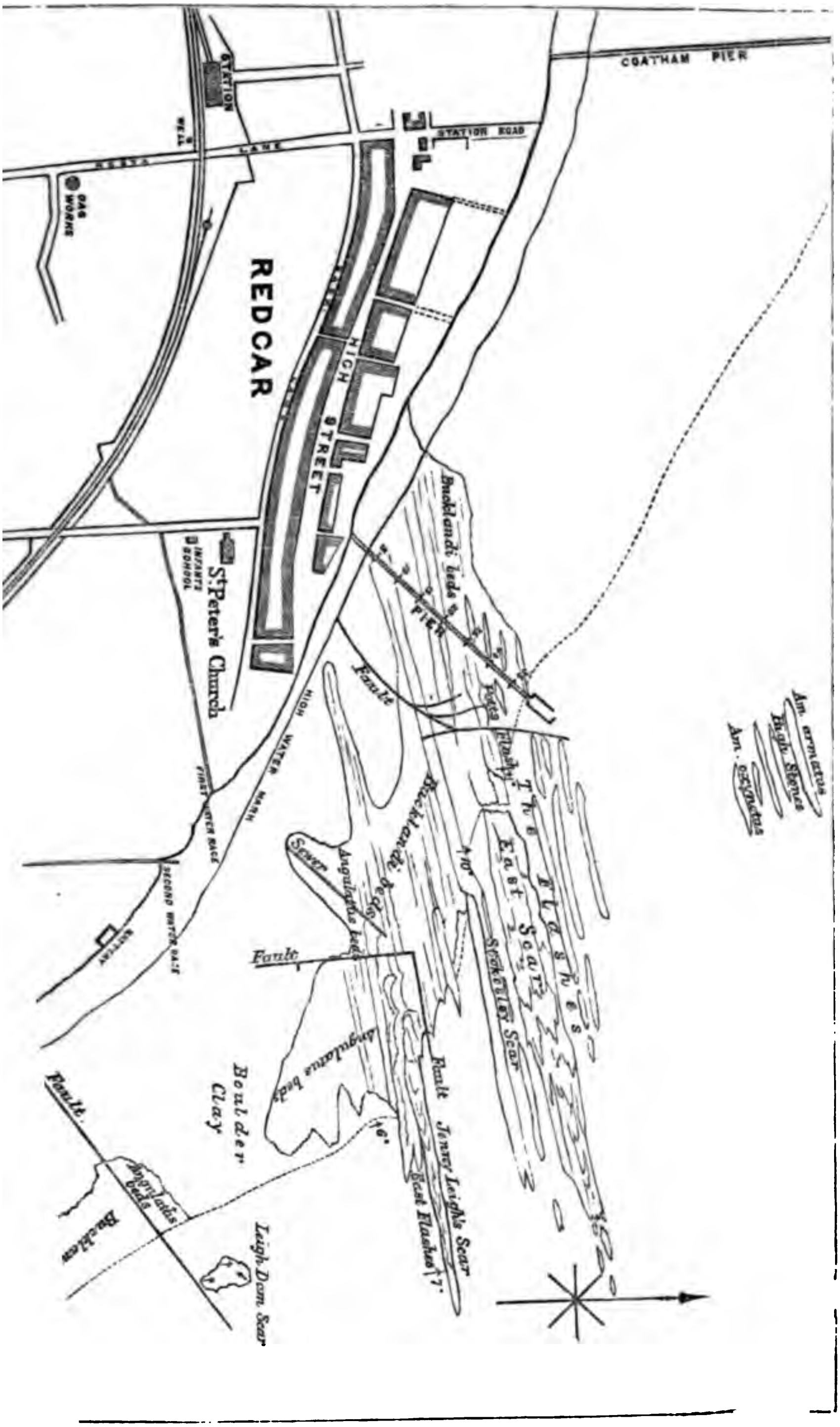
In the lower portion there are many fossils, belonging to a moderate number of species; but as we ascend in the series the species rapidly diminish in number, and, with the exception of a few Ammonites, there is no accession to the fauna, which finally consists of *Cardinia Listeri*, *Gryphæa arcuata*, *Lima gigantea*, *L. pectinoides*, *Monotis inæquivalvis*, *Belemnites acutus*, and *Ammonites Turneri*.

The chief fossils of the upper series are *Ammonites Turneri*, *A. semicostatus*, *A. difformis*, *A. Sauzeanus*, *Belemnites acutus*, *B. infundibulum*, *Cardinia Listeri* (vars. *hybrida* and *cuneata*), *Pecten Thiollieri*, *Monotis inæquivalvis*, *Spiriferina Walcotti*, *Acrodus nobilis*.

The accompanying plan of the Redcar Rocks, and the tabulated section of the beds, will prove useful to those desirous of investigating in detail this extensive and interesting group of strata. The occasions, however, when so large an expanse of rock is in view, as we have shown on the plan, are few; and we have not unfrequently found the whole strand above ordinary low tides to be composed of sand.

Our plan of collecting the fossils is to crawl along the scars, during a bright sunny day, in a position so as not to intercept the direct rays of sunlight—also to wash the fossiliferous shales, as is done for Foraminifera, only that what is retained by the sieve will yield the small molluscan shells.

Fig. 2.


COATHAM PIER
STATION
STATION ROAD
WELL
LANE
GAS WORKS
REDCAR
HIGH STREET
St. Peter's Church
INFANTS SCHOOL
PIER
HIGH WATER MARK
FIRST WATER RACE
SECOND WATER RACE
Fault
Bucklandi beds
The Flashes
East Scar
Stokesley Scar
Bucklandi beds
Angulatus beds
Sewer
Fault
Angulatus beds
Boulder Clay
Fault
Jenny Leigh's Scar
East Flashes
Fault
Angulatus beds
Leigh Dam Scar
Am. armatus
High Stones
Am. oxynotus

VERTICAL SECTION.—REDCAR SCARS.

No.	Lithology.	Thickness. ft. in.	Fossils.	Remarks.
1.	Calcareous shale, unseen	23 6	*Ammonites-oxynotus* beds.	Long reef, "High stone," in the Bay.
			UPPER BUCKLANDI-BEDS.	
2.	Calcareous shale &c.	10 0	*Am. semicostatus, Gryphæa arcuata*	Scar supports column no. 37 on the west*.
3.	Calcareous shale &c.	8 0		Scar, column no. 35.
4.	Calcareous shale, with limestone nodules and oyster-bed	1 0	*Am. semicostatus, Pecten calvus, P. Thiollieri, Monotis inæquivalvis, Gryphæa arcuata*	Scars between columns nos. 33 and 32.
5.	Calcareous and friable shales	4 0	*Am. Turneri, Pecten Thiollieri, Gryphæa arcuata.*	
6.	Indurated grey shales	4 0		Scar, column no. 30.
7.	Soft blue shales; black limestone nodules at base	16 6 (7–8)	*Am. Turneri, A. bisulcatus, Belemnites infundibulum, Cardinia Listeri* et var. *hybrida, C. concinna, Lima gigantea, L. succincta, Hippopodium, Pleuromya galathea, Monotis inæquivalvis, Pecten textorius, Gryphæa arcuata*	Scar.
8.	Friable sandy shales			
9.	Indurated shales	3 6	*Am. Turneri, A. bisulcatus, Lima gigantea, Cardinia Listeri.*	
10.	Smooth blue shale with small cylindrical nodules of black limestone	11 0	*Ammonites bisulcatus, A. Scipionanus* (small)	"The Flashes."
11.	Friable shale with black limestone nodules	3 9 (11–12)	*Ichthyosaurus, Acrodus nobilis, Am. Bucklandi, A. Sauzeanus, Belemnites acutus, Gervillia Hagenovii, Cardinia Listeri, Spiriferina Walcotti*	Top scars of the East Scar, between columns 19 & 22.
12.	Hard calcareous shales and oyster-band			
13.	Oyster-band and earthy limestone	1 3		Main side of East Scar. Column no. 19, on east side, stands upon it.
14.	Calcareous shale, with nodules	1 9	*A. Bucklandi, A. Sauzeanus* (common and large), *Monotis inæquivalvis*	
15.	Soft shale	0 6	*A. Sauzeanus.* (15–16)	
16.	Limestone	0 8		
17.	Oyster-band	0 11 (17–19)		Scar, column no. 18, on east side, stands upon it.
18.	Shaly limestone			
19.	Hard calcareous shale			

		ft.	in.		
	MIDDLE BUCKLANDI-BEDS.				
20.	Friable shale	1	0		
21.	Oyster-bank	0	3		
22.	Hard shale, with black limestone nodules	0	4		
23.	Friable shale	0	10		
24.	Shale	1	10		
25.	Limestone	0	6		
26.	Soft shale	0	5		
27.	Oyster-band	0	0¼	*Gryphæa arcuata.*	
28.	Soft shale	0	8		
29.	Shale with nodules	0	10		
30.	Limestone	0	1½	*Ammonites Bucklandi*, *Gryphæa arcuata.*	
31.	Hard shale	3	6		
32.	Earthy limestone mixed with shale	0	9		
33.	Friable shale	3	0	*Ammonites bisulcatus*	Lowest ridge of the East Scar.
34.	Soft shale	12	0	*A. bisulcatus*, *A. Charmassei*, large *Cardinia concinna.*	
35.	Oyster-bed, 1 inch			*Gryphæa arcuata*, *Lucina limbata*, *Hippopodium*, *Myoconcha*, *Pecten textorius*, *Cardinia concinna* (small).	
36.	Soft shale, with nodules				
37.	Oyster-bed, 1 inch	9	0		
38.	Soft shale				
39.	Oyster-bed, 1 inch				
40.	Stiff blue shale				
41.	Oyster-bed in friable shale	0	3	*G. arcuata*, *Monotis inæquivalvis*, *Card. hybrida*, *Hippopodium*, *Macrodon hettangiensis*, *Mytilus hillanoides*, *Cidaris Edwardsi.*	Low Scar.
42.	Stiff blue shale	1	0	*Monotis* and *Mytilus hillanoides.*	
43.	Shale with black limestone nodules	0	2		
44.	*Cardinia*-bank	0	3	A dense mass of *Cardinia Listeri* et var. *hybrida*, *Unicardium cardioides* and *Gryphæa arcuata*	Surface of Stokesley Scar.
	Carried forward	36	9		

* As a guide to the respective positions of the more interesting beds of the M. and U. *Bucklandi*-series, we have indicated what columns on the west or east side of Redcar Pier stand on them.

MIDDLE BUCKLANDI-BEDS (*continued*).

No.	Lithology.	Thickness. ft.	in.	Fossils.	Remarks.
	Brought forward	36	9		
45.	Friable shale	0	7	*Eucyclus elegans*, *Lima pectinoides*	
46.	Friable shale and oyster-bed	0	4		
47.	Friable shale and oyster-bed	0	8	*Dentalium etalense*, *Lima gigantea*, *Cardinia Listeri*	
48.	Friable shale and oyster-bed	0	6	*L. gigantea*, *C. Listeri*, *Pentacrinus tuberculatus*	
49.	Friable shale, with nodules and oyster-bed	0	8	*Am. bisulcatus*, *A. Charmassei*, *Eucyclus elegans*, *Pleurotomaria similis*, *P. concava*, *Turbo solarium*, *T. Philemon*, *Pitonellus*, *Cryptænia*, *Turritella Dunkeri*, *Actæonina fragilis*, *Dentalium etalense*, *Myoconcha*, *Monotis inæquivalvis*, *Lucina*, *Ledæ*, *Macrodon navicula*, *Unicardium*, *Cardinia Listeri*, *Modiola hillanoides*, *M. bifasciata*, *Cardita*, *Protocardium*, *Lima gigantea*, *L. pectinoides*, *Pecten textorius*, *Gryphæa arcuata*, *Rhynchonella plicatissima* (var.), *Ditrypa antiquata*, *Pentacrinus*, *Montlivaltia Guettardi*, *M. Haimei*	Stokesley Scar. These beds intersect the line of Redcar Pier between the 6th and 9th columns on the west side.
50.	Friable shale and oyster-bed	0	4	*C. Listeri*, *Lima pectinoides*, *Pecten textorius*, *Pentacrinus*	
51.	Oyster-bank	0	1	*L. pectinoides*, *P. textorius*, *Pentacrinus*, *Cryptænia solarioides*	
52.	Stiff blue shale	0	9		
53.	Line of blue limestone nodules	0	1½		Base of Stokesley Scar.
54.	Stiff blue shale, with flat blue limestone nodules	7	0	*Cardinia concinna.*	
55.	Friable shale with oyster-bed	0	1½	*Pecten textorius*, *Montlivaltia Guettardi.*	
56.	Stiff blue shale	5	0	*Ammonites Birchii.*	
57.	Oyster-band		1		
58.	Friable shale and depressed limestone nodules	0	2	*G. arcuata*, *Cardinia Listeri*, *Unicardium*, *Modiola hillanoides*, *Pecten textorius*, *Rhynchonella plicatissima* (var.), *Am. Charmassei*	Supports Pier no. 4, on east side.
59.	Stiff blue shales	17	0	*Nautilus striatus*, *Pleuromya crassa*, and *Pentacrinus tuberculatus*, on drift wood.	
60.	Thin calcareous sandstone and stiff blue shales	9	0		

		ft.	in.		
61.	Oyster-band 1 inch, shale 3 inches, calcareous sandstone ½ inch	0	4½		
62.	Stiff blue shale	14	0		
	Total	93	6½		
	Lower Bucklandi-beds.				
	Friable shale with indurated top	3	2		
64.	Earthy limestone in nodules	0	2		
65.	Friable shale	0	11½	*Rissoa nana, T. solarium, T. philemon, Discohelix semistriatus, D. Oppeli, Dentalium etalense, D. limatulum, Macrodon navicula, M. pulla, Leda galathea, L. texturata, Nucula navis, Astarte obsoleta, Tancredia ovata, &c., Monotis papyria*	Scar at low water, 25 paces west of main ridge of Jenny Leigh's Scar.
66.	Lumpy limestone	0	3	*Ammonites bisulcatus*	Low scar.
67.	Friable shale	0	1		
68.	Soft shale	0	2		
69.	Nodular limestone	0	2	*Am. Bucklandi, Gryphæa arcuata.*	
70.	Shale	0	4		
71.	Gryphite limestone	0	3	*Am. Bucklandi, Cryptænia, G. arcuata*	Scar.
72.	Soft shale	0	6		
73.	Limestone	0	2½	*Am. Bucklandi*	Main ridge of Jenny Leigh's Scar.
74.	Shale	0	6		
75.	Gryphite limestone	0	7		
76.	Shale	0	2		
77.	Limestone	1	0		
78.	Shale	0	2		
79.	Limestone	0	3		
80.	Soft shale	0	1		
81.	Limestone mixed with shale	0	3½		
82.	Soft shale	0	1		
83.	Lumpy limestone	0	3		Scar.
84.	Friable shale with oysters	0	6		
85.	Nodular limestone	0	3		
	Carried forward	10	4½		

Lower Bucklandi-beds (*continued*).

No.	Lithology.	Thickness. ft.	in.	Fossils.	Remarks.
	Brought forward	10	4½		
86.	Soft shale	0	5		
87.	Limestone mixed with shale	0	8	*Ammonites Conybeari*	Scar.
88.	Soft shale	0	4		
89.	Friable shale and stone	0	8	*Pleurotomaria similis*, *Eucyclus elegans*, *Lima gigantea*, *L. pectinoides*, *Myoconcha*, *Lucina*, *Hippopodium*, *G. arcuata*	Scar.
90.	Soft shale	0	9	*Plicatula liasina*, *Galeolaria socialis*, *Cidaris*, *Pentacrinus*, *Am. bisulcatus*	
91.	Friable shale and limestone	0	3		
92.	Soft shale	1	1		
93.	Friable shale with stony portions	0	2		
94.	Soft shale	0	2		
95.	Limestone	0	4		
96.	Friable shale with limestone	0	4		Scar.
97.	Soft shale	0	9		
98.	Limestone 1¼ in., lumpy limestone 2 in.	0	3½	*Nautilus striatus*, *Astarte obsoleta*, *Leda galathea*, *Pinna Hartmanni*	Scar.
99.	Soft shale	1	6		
100.	Soft and friable shales	0	5		
101.	Shell-limestone, friable shales	0	6	*Am. Bucklandi*, *Am. Conybeari*, *Pleurotomaria similis*, *Eucyclus elegans*. *Cryptænia solarioides*, *Astarte obsoleta*, *Ditrypa globiceps*, *Galeolaria socialis*	Lowest ridge of Jenny Leigh's Scar.
102.	Line of limestone nodules, shales of the *angulatus*-zone				
	Total	19	0		
	Total of the *Bucklandi*-series	179	4½		

Next in interest to the scars at Redcar, which exhibit completely the relations of the *Bucklandi*- to the *angulatus*-beds, and carry us well up in the series, come those at the S.E. end of Robin Hood's Bay, which give us the relations of these beds to the overlying zone of *Am. oxynotus*. The latter, however, are disadvantageously situated for study, as they are remote from any town, and are even two miles from the nearest village; and while at Redcar the scars have their strike at a high angle with the shore-line, leaving parts of all of them explorable even at half-tide, those at Robin Hood's Bay are parallel to the shore, and but few of them ever become dry; the lower ones are just uncovered at ebb tide, and the highest only at half-tide. Their position at Robin Hood's Bay is very well marked. Beyond Stow Beck is seen rising a strong band of rock 2 ft. thick, which as the strata rise approaches the shore, and finally becomes parallel to it and separates the scars from the beach. This is the lowest bed of the *oxynotus*-series. It is so hard and weatherworn that few fossils have been found in it; below, however, *A. Turneri* and associated fossils occur, and above it *A. obtusus*, which is the characteristic Ammonite of the lowest region of the zone of *A. oxynotus*: some 6 feet above this is another, thinner hard band, which is not so continuous and must not be confounded with it. The thickness of these rocks can only be estimated by the breadth of the flats between the scars; and in this respect an error, difficult of elimination, creeps in, because the outer scars are necessarily cut off at a lower level than the inner, and they also stand at varying heights above the general slope. The estimated thicknesses can therefore only be regarded as approximate.

The following, however, is the exposed section:—

No.	Lithology.	Thickness. ft. in.	Fossils.
	Hard calcareous rubbly shale, forming strong scar.	10 3	
	Blue shale with layers of oysters.	2 4	
	Indurated limestone band ...	0 4	
	Blue shale, with *A. planicosta*	3 6(*e*)	(*e*) Estimated thickness.
	Base of *oxynotus*-beds		
1.	Indurated calcareo-argillaceous band, rubbly, speckled, brownish.	0 2	
2.	Blue shale, harder at the top, with oysters in nests (forming the first broad scar).	5 0(*e*)	*Am. Turneri*, *Belemnites acutus*, *Monotis inæquivalvis*, *Gryphæa arcuata*, *Cerithium*, *Lucina limbata*, *Pholadomya glabra*, *Pleuromya* sp., *Modiola lævis*, *Leda galathea*, *Leda Renevieri*, *Hippopodium ponderosum*, *Perna infraliassica*.

LOWER BUCKLANDI-BEDS (*continued*).

No.	Lithology.	Thickness. ft.	in.	Fossils.	Remarks.
	Brought forward	10	4½		
86.	Soft shale	0	5		
87.	Limestone mixed with shale	0	8	*Ammonites Conybeari*	Scar.
88.	Soft shale	0	4		
89.	Friable shale and stone	0	8	*Pleurotomaria similis, Eucyclus elegans, Lima gigantea, L. pectinoides, Myoconcha, Lucina, Hippopodium, G. arcuata*	Scar.
90.	Soft shale	0	9	*Plicatula liasina, Galeolaria socialis, Cidaris, Pentacrinus, Am. bisulcatus*	
91.	Friable shale and limestone	0	3		
92.	Soft shale	1	1		
93.	Friable shale with stony portions	0	2		
94.	Soft shale	0	2		
95.	Limestone	0	4		
96.	Friable shale with limestone	0	4	....	Scar.
97.	Soft shale	0	9		
98.	Limestone 1½ in., lumpy limestone 2 in.	0	3½	*Nautilus striatus, Astarte obsoleta, Leda galathea, Pinna Hartmanni*	Scar.
99.	Soft shale	1	6		
100.	Soft and friable shales	0	5		
101.	Shell-limestone, friable shales	0	6	*Am. Bucklandi, Am. Conybeari, Pleurotomaria similis, Eucyclus elegans, Cryptænia solarioides, Astarte obsoleta, Ditrypa globiceps, Galeolaria socialis*	Lowest ridge of Jenny Leigh's Scar.
102.	Line of limestone nodules, shales of the *angulatus*-zone				
	Total	19	0		
	Total of the *Bucklandi*-series	179	4½		

Next in interest to the scars at Redcar, which exhibit completely the relations of the *Bucklandi-* to the *angulatus*-beds, and carry us well up in the series, come those at the S.E. end of Robin Hood's Bay, which give us the relations of these beds to the overlying zone of *Am. oxynotus*. The latter, however, are disadvantageously situated for study, as they are remote from any town, and are even two miles from the nearest village; and while at Redcar the scars have their strike at a high angle with the shore-line, leaving parts of all of them explorable even at half-tide, those at Robin Hood's Bay are parallel to the shore, and but few of them ever become dry; the lower ones are just uncovered at ebb tide, and the highest only at half-tide. Their position at Robin Hood's Bay is very well marked. Beyond Stow Beck is seen rising a strong band of rock 2 ft. thick, which as the strata rise approaches the shore, and finally becomes parallel to it and separates the scars from the beach. This is the lowest bed of the *oxynotus*-series. It is so hard and weatherworn that few fossils have been found in it; below, however, *A. Turneri* and associated fossils occur, and above it *A. obtusus*, which is the characteristic Ammonite of the lowest region of the zone of *A. oxynotus*: some 6 feet above this is another, thinner hard band, which is not so continuous and must not be confounded with it. The thickness of these rocks can only be estimated by the breadth of the flats between the scars; and in this respect an error, difficult of elimination, creeps in, because the outer scars are necessarily cut off at a lower level than the inner, and they also stand at varying heights above the general slope. The estimated thicknesses can therefore only be regarded as approximate.

The following, however, is the exposed section:—

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Hard calcareous rubbly shale, forming strong scar.	10 3	
	Blue shale with layers of oysters.	2 4	
	Indurated limestone band ...	0 4	
	Blue shale, with *A. planicosta*	3 6(*e*)	(*e*) Estimated thickness.
	Base of *oxynotus*-beds		
1.	Indurated calcareo-argillaceous band, rubbly, speckled, brownish.	0 2	
2.	Blue shale, harder at the top, with oysters in nests (forming the first broad scar).	5 0(*e*)	*Am. Turneri, Belemnites acutus, Monotis inæquivalvis, Gryphæa arcuata, Cerithium, Lucina limbata, Pholadomya glabra, Pleuromya* sp., *Modiola lævis, Leda galathea, Leda Renevieri, Hippopodium ponderosum, Perna infraliassica.*

No.	Lithology.	Thickness. ft. in.	Fossils.
3.	Blue limestone formed of comminuted shells, scarcely pyritous.	0 3	*Pecten textorius.*
4.	Blackish blue crumbly shale with two harder bands in the middle.	2 6(*e*)	*G. arcuata, Cardinia hybrida, Modiola lævis, Pleuromya, Nucula navis, Lucina limbata, Hippopodium ponderosum, Pecten calvus, Am. Turneri.*
5.	Rubbly indurated band, speckled brown.	0 2	
6.	Soft shale, crumbly, not very fossiliferous.	0 8	
7.	Calcareous rough shale	0 8	*Modiola lævis.*
8.	Blue shale, papery, with nodules.	4 6(*e*)	*Am. Turneri, Modiola lævis, Lucina limbata, Cardium oxynoti.*
9.	Hard shell-limestone, comminuted, pyritous in middle.	0 6	*Gryphæa arcuata, Pecten textorius.*
10.	Blue-black shales with oyster layers, papery.	2 8(*e*)	*Am. semicostatus, Lucina limbata, Cardium oxynoti, Modiola lævis, Cerithium* sp., *Leda galathea, P. textorius, Leda Renevieri.*
11.	Hard earthy not pyritous shell-limestone.	0 2	*Lucina limbata.*
12.	Dark crumbly shale	1 0(*e*)	*Cardium oxynoti, Lucina limbata, Modiola lævis, Cerithium* sp., *Pleuromya* (cf. *elongata*).
13.	Shell-limestone, very pyritous	0 1	*G. arcuata, Lucina limbata.*
14.	Thin-splitting blue shale with doggers.	0 8(*e*)	*Pecten textorius.*
15.	Shell-limestone..................	0 1	*Lucina limbata, Leda galathea.*
16.	Blue shale, with dogger near the top, with irregular shell-bands.	3 0(*e*)	*Am. semicostatus, Monotis inæquivalis, Leda Renevieri, Dentalium etalense, Cardium oxynoti, Leda galathea, Pecten calvus, Pleuromya* (cf. *elongata*), *Lucina limbata.*
17.	Red ironstone dogger, blue inside.	0 1	Wood, *Dentalium etalense.*
18.	Brown oyster-band, with calcareous crystals in joints.	0 4	*G. arcuata, Pecten Thiollieri, Ichthyosaurus.*
19.	Blue-black shales with septaria	1 4(*e*)	*Lucina limbata, Gryphæa arcuata, Lima hettangiensis, Cerithium* sp., *Leda galathea, Leda Renevieri, Cardium oxynoti, Am. semicostatus, Aptychus,* wood.
20.	Shell-limestone	0 1	*Lucina limbata, Pecten Thiollieri, G. arcuata, Belemnites acutus.*
21.	Shale with red iron-band, in parts with fucoids.	3 6(*e*)	*Ditrypa* sp., *Lucina limbata.*

Six or 7 feet of rough irregular shales with similar limestone partings and thin ironstone bands may be walked on at low tides; beyond this at very low tides, perhaps about 20 feet below, is a very strong band seen standing out, looking at least 2 feet thick, probably the source of the strong limestone with *Ammonites semicostatus* &c.; and about 6 feet below that again another ledge is occasionally uncovered; and even beyond this there must be others near the surface, from the presence of lines of breakers. In the last shale that can be walked on we find the following—*Euomphalus* sp., *Cerithium* sp., *Am. semicostatus, A. geometricus, Pecten calvus, P. æqualis, Lucina limbata, Lima pectinoides, Belemnites acutus, Leda galathea, Unicardium cardioides, Ditrypa.*

We have thus some 30 or 40 feet of *Bucklandi*-beds exhibited here; probably the estimated thickness is below the truth; we do not, however, reach to the Middle series as exhibited at Redcar, but almost commence where that leaves off. The most characteristic fossils of these beds are *Am. semicostatus, Lucina limbata, Leda galathea*, and in the upper part *Ostrea arcuata* and *Modiola lævis.* In this also occur the large Ammonites which have often been called *A. Bucklandi*, but which more probably belong in most cases to *A. Turneri.* These beds can scarcely have been deposited under the same conditions as those at Redcar, as there is no falling-off in the fauna here—the majority of the beds being equally fossiliferous, and some containing the greatest variety occurring near the top.

OTHER EXPOSURES AND SECTIONS OF THE *Bucklandi*-BEDS.

Coatham Sandbanks.—The hard stone bands of the *Bucklandi*-series without doubt form the ridge on which the towns of Redcar and Coatham are built; but of this we have no positive evidence: however, peeping out among the sand-hills opposite the Coast-guard station at Coatham, and on the north side of the old railway, there is a small patch of the Upper series of the *Bucklandi*-beds. The strata dip $8\frac{1}{2}°$ seaward, and consist, in descending order, of:—

	ft.	in.
Rubbly iron-stained limestone	1	0
Dense friable shale, full of *Ostrea*	2	6
Shelly limestone	0	6
Blue shale.		
	4	0

The fossils observed were *Ammonites Bucklandi, A. Sauzeanus, Belemnites calcar, Lima gigantea, L. pectinoides, Pecten Thiollieri, Lucina limbata, Cardinia hybrida, Unicardium cardioides, Monotis inæquivalvis, Modiola Hillana*, and *Ostrea arcuata.*

On the south bank of the railway and a little west of the last station, and about 160 yards west of the bridge, a small excavation made in 1873 disclosed a thin band of shelly argillaceous limestone crowded with *Ostrea arcuata.*

Marske Bay.—Two very important exposures are occasionally to

be seen at the low spring tides on this shore—one to the east and in juxtaposition with the *angulatus*-beds at Redcar, and the other opposite Red Howls, about one mile west of Marske.

In the account of the *angulatus*-beds at Redcar it is stated that they have been brought to the surface by a fault, on the east side of which are shales belonging to the *Bucklandi*-series. These latter have been traced continuously for a distance of 380 yards, reaching opposite to the break in the sandbanks called Leigh Dam. For a considerable distance beyond the fault there are blue shales, with small kidney-shaped limestone connexions, but no fossils, and showing no perceptible dip; but higher up on the beach similar shales have scattered thoughout them large examples of *Ostrea arcuata*; these are obviously superimposed on the former. Passing towards the eastern part of the exposure a calcareous sandstone, 1½ inch thick, containing Encrinites, is seen overlying the blue shales; and beyond we encounter stiff blue shales with a few, chiefly small, fossils: the whole of these exhibit a slight, though decided dip to the south east. The fossils of the last-mentioned shales, as well as the mineral character of the whole mass, serve to correlate them with the middle portion of the *Bucklandi*-beds, and especially with the strata (Nos. 59–61, p. 60) underlying the beds of Stokesley Scar at Redcar.

The species are *Ammonites Charmassei*, *Dentalium etalense*, *Leda galathea*, *Monotis inæquivalvis*, *Astarte irregularis*, *Nucula navis*, *Modiola lævis*, *Pleuromyæ*, *Ostrea arcuata*, *Pentacrinus tuberculatus*, *Lima succincta*.

At a distance of a little more than half a mile to the east is the other exposure, which, when measured by us, had a length of 100 yards, and a breadth of 60, displaying the following succession of beds dipping at an angle of 3° to the S.E. On the extreme N.W. part of the patch there occur blue shales overlain by grey sandy shale containing *Ostrea arcuata* and *Ammonites bisulcatus*.

A band of shelly limestone, 2 inches thick, is distant 40 feet from the N.W. end. This is succeeded by alternations of soft blue micaceous shales, and hard sandy and calcareous shales, sometimes separating into slabs; nodules occur in all the beds, but are more abundant in the higher ones.

The limestone band and underlying shales have yielded a variety of fossils, the chief of which are *Ammonites Sauzeanus*, *A. Scipionanus*, *Belemnites acutus*, *Cardinia hybrida*, *C. crassiuscula*, *Lima succincta*, *Hippopodium ponderosum*, *Unicardium cardioides*, and *Spiriferina Walcotti*.

The highest bands of shales contain *Ammonites bisulcatus*, *A. semicostatus*, *A. difformis*, *A. Sauzeanus*, *Belemnites acutus*, *Phasianella Morencyana*, *Cardita Heberti*, *Macrodon hettangiensis*, *M. pullus*, *Leda galathea*, *Nucula navis*, *Astarte obsoleta*, *Lima pectinoides*, *Unicardium cardioides*, *Cardinia hybrida*, and *Spiriferina Walcotti*.

We do not hesitate to refer these beds to the horizon of the upper part of the *Ammonites-Bucklandi* zone; and as they have a dip to the S.E., contrary to that of the correlated beds at Redcar, we have clear evidence of the anticlinal fold, the axis of which must intersect

the line of coast about midway between the two outcrops (see section).

Nunthorpe.—The removal of the whinstone in the Nunthorpe quarries has brought to view an extensive section of the Lower Lias beds on the horizon of *Ammonites Bucklandi.* Throughout the whole length of about a quarter of a mile the bounding walls of the dyke are constituted of micaceous shales and calcareous shale, with nodules and a few stone bands; but from the induration that has been effected by the igneous intrusion, neither the lithological characters of the beds nor the species of the fossils can be determined with accuracy. The lowest beds visible, which may be examined with more satisfactory results in the road-cutting entering the quarries on its S.W. corner, consist of shales with small cylindrical limestone nodules and harder calcareous shales containing, in the form of casts, *Ammonites semicostatus, Pecten Thiollieri, Cardinia hybrida, Lucina limbata, Hippopodium ponderosum, Unicardium cardioides, Ostrea arcuata,* and *Eryon* sp.

The depth of the quarries is about 25 feet; and on the eastern end, adjacent to Roundhill, recur a similar set of beds yielding *Am. semicostatus, Belemnites,* and other fossils of the *Bucklandi*-series; between the two points, a quarter of a mile distant, the beds have a dip of less than 1°, so that the aggregate thickness of the *Bucklandi*-series seen here is not more than 40 feet.

Osmotherley District.—*Bucklandi*-shales are exposed in the roadside leading from the church at East Harlsey to Morton Grange.

Ellerbeck.—On the north bank of Cod Beck, at about 700 yards west of Ellerbeck Mill, thin earthy limestones and shales are in view beneath the gravel deposit which covers so extensive an area in this district; these liassic strata are exhibited immediately beneath the hovel designated on the Survey Map Crab Hall; but further west and near to the ford the following section may be observed:—

	ft.	in.
1. Sandy shales—*Am. semicostatus, Ost. arcuata*	1	8
2. Earthy arenaceous limestone—*Nautilus striatus*	1	8
3. Earthy shales—*Cardinia crassiuscula, C. hybrida*	0	7
4. Shell-limestone—*Lucina, Cardiniæ, Ostrea*	0	2
5. Shales with limestone balls and thin stone bands—*Belemnites acutus*	5	0

Fossils—*Ammonites semicostatus, A. bisulcatus ?, Nautilus striatus, Belemnites acutus, Ostrea arcuata, Cardinia crassiuscula, C. Listeri* et var. *hybrida, Lima succincta, L. gigantea, L. pectinoides, Pecten Thiollieri, Pinna Hartmanni, Unicardium cardioides, Lucina limbata, Cidaris Edwardsi.*

The beds here described clearly belong to the upper part of the *Bucklandi*-series.

A little to the west of the last section, there is another on the south side of the mound called Dun-Close Hills, and which may be reached by following the course of the stream. Here, earthy and gryphitic limestones occur among blue stiff shales, the whole belonging to some part of the *Bucklandi*-beds; their proximity to the

"*Pleuromya*-limestones" in Foxton Lane is suggestive of a lower level than that of the Ellerbeck section.

On approaching Sigston Smithy from the Ellerbeck section, an obscure exposure of the *Bucklandi*-beds is noticeable on the roadside by Willow-tree House; though insignificant, yet importance is to be attached to this determination, inasmuch as it fixes a westerly limit to the course of the Sigston fault.

On the west side of Cod Beck this Gryphite-limestone is traceable as far south as High-Crosby Cote, forming the top of a scarped terrace, being the eastern boundary of the liassic plateau, the western terminations of which are made by the *Pleuromya*-limestones and other hard bands situate towards the base of the formation, as already described, p. 32.

Southern Area.—In the stream at the side of "Backlane" at Howsham all the large stones consist of fragments of oyster-bands of this series, *i. e. Ostrea arcuata*; and the same may be found along the south side of the hill by the springs; so that, though not seen, they probably occur here; and in this case the lower zones must be very thin or absent, as the Keuper is close below.

Along Gilder and Baffham Becks, to the west and south of Hanging Grimston, many indications of this zone appear, by the frequency of Gryphite-limestone. To the south side of a fault which throws up the Lias against an outlier of Oolite, just north of Kirby Underdale, these limestones were met with *in situ* in a well-sinking.

The *Bucklandi*-beds of Garrowby Beck have been already mentioned in connexion with the lower zone of *A. angulatus*.

In the disturbed strata of the brick-yard near Warter, where the *armatus*-beds are exposed, as will be mentioned in the sequel, the lowest beds visible, which stand almost vertical on the east side of the pit, belong to this zone—*Ostrea arcuata* and *Belemnites acutus*, with other badly preserved fossils being numerous. On the south side of a small hollow in the chalk immediately to the east of Nunburnholme these Gryphite-beds may be seen *in situ* overlapped by the Red chalk.

In a plantation to the east of Goodmanham, there are springs rising from these beds, where they are exposed *in situ* lying at the top of the plantation, the *angulatus*-beds as before mentioned occurring lower down.

To the south of Market Weighton the *Bucklandi*-beds are not very satisfactorily exposed. If we walk along the top of the hill which runs parallel to the Cliff and Hotham road, and in which are the pits before described as displaying the lower zones, we meet everywhere with *Ostrea arcuata* in great abundance; but any pit or break shows that they have not been worked up from beds *in situ*, but that they have been washed out by some rapid current and redeposited as gravel, mixed, in some instances, with the intervening clays. To the south, at Ellerker, this is very manifest; the whole ground is covered with nothing but these oysters, which are used for roadstone. Good gravel-pits of this sort may be seen at the top of the hill above North Cliff, and on either side of the road leading from North to South Cave. Here the current must have been of the wildest, as the

beds are most irregular, and large intervals are left between the different stones, as may be seen too in the oolitic gravel-pits in the neighbourhood of Brough. There can be no doubt that the *Bucklandi*-beds occupy the western portion of the whole of the top of the before-mentioned range of low hills; and they gradually reach the more level ground as the strata descend; and they are at last seen, *apparently in situ*, in a small pit on the right hand of the road from North Cave to Hotham: in the former place they are met with in the well-sinkings.

With respect to the Gryphite-gravel, it is remarkable that beds of this kind consisting purely of Gryphites and Belemnites are met with in patches across the chalk wolds, as at Brandesburton. In the northern area, specimens of *Ostrea arcuata* occur in many localities far removed from, and often at considerable elevations above, the outcrops of the Gryphite-beds. They are frequent in the gravels which occupy the bed of the Skelton beck from Slapewath, 350 feet above the sea-level to Upleatham; and in no part of its course does it traverse Lower Lias strata. They have occurred in the thin Boulder-clay cover at Lingdale on Hanghow Moor, at an elevation of 600 feet above the sea. At Green Hill, about three quarters of a mile west of Osmotherley, a gravel-pit has been opened at 660 feet above the sea-level, and worked to a depth of 20 feet; the gravel is subangular and rudely stratified, and contains a profusion of the common oyster of the *Bucklandi*-beds; overhanging Osmotherley corn-mill, a similar gravel is consolidated, and at one spot shows a vertical face of 7 feet.

PALÆONTOLOGY OF THE ZONE OF *Ammonites Bucklandi.*

Comparison of the Faunas of the angulatus- *and* Bucklandi-*beds.*—The leading palæontological features of the zone of *Ammonites Bucklandi* have already been indicated; and we have now to justify the separation of the *angulatus*- from the *Bucklandi*-beds.

The *Bucklandi*-zone has yielded	174 species,	or	138	less the	Foraminifera.
The *angulatus*-zone has yielded	149 ,,	,,	113	,,	,,
Difference	25		25		

The representatives of each class, excepting the Cephalopoda, are about equal in number in the two zones, the excess of Cephalopods in the higher horizon nearly making the difference of numbers of species (excluding Foraminifera) between the two faunas.

Using as data for comparison the mere occurrences, actual and inferred, of species in the two zones, irrespective of their relative degrees of frequency, we shall find that the community of species thus so crucially tested is not considerable, as may be gathered from the subjoined Table.

	Species peculiar to *A. angulatus*-zone.	Species peculiar to *A. Bucklandi*-zone.	Species common to both zones.	Total species in the two zones.
Reptiles	0	0	2	2
Fishes	2	2	0	4
Cephalopoda	4	23	3	30
Gasteropoda	8	11	18	37
Lamellibranchs	13	14	34	61
Palliobranchs	1	1	3	5
Crustacea	3	4	7	14
Annelides	0	1	6	7
Echinoderms	1	2	4	7
Corals	2	1	1	4
Plants	1	1	0	2
	35	60	78	173
Percentage of common species 45.				

A greater contrast would be noted by the casual observer having before him only the more frequently occurring species of each zone; whilst in the above survey the single occurrence, *e.g.*, of *Cryptænia solarioides* in the *angulatus*-beds counterbalances the hundreds of examples obtained from the *Bucklandi*-zone, and so also with many other species.

List of Fossils of the Bucklandi-*zone.*

Ichthyosaurus, sp.
Acrodus nobilis.
Hybodus reticulatus.
Ammonites Charmassei.
—— Bucklandi.
—— bisulcatus.
—— Brooki.
—— Conybeari.
—— Turneri.
—— sinemuriensis.
—— Scipionanus.
—— Sauzeanus.
—— semicostatus.
—— rotiformis.
—— Bodleyi.
—— finitimus.
—— Pauli.
—— difformis
—— Pellati.
—— spinarius.
—— niger.
—— Greenoughi.
—— Birchii.
—— multicostatus.
—— nodulosus.
Belemnites penicillatus.
—— calcar.
—— acutus.
—— infundibulum.
Nautilus striatus.
Dentalium etalense.
—— limatulum.
Actæonina fragilis.
—— sinemuriensis.
Pleurotomaria similis.
—— Hennocqui
—— concava.
—— tectaria.
Cryptænia solarioides.
—— rotellæformis.
Turbo solarium.
—— philemon.
—— reticulatus.
—— Wilsoni.
Rissoa nana.
Phasianella Morencyana
Pitonellus sordidus.
Eucyclus elegans.
—— selectus.
Trochus redcarensis.

Chemnitzia Collenoti.
—— unicingulata.
Cerithium gratum.
—— semele.
Turritella Zenkeni.
—— regularis.
—— Dunkeri.
—— crassilabrata.
Discohelix Oppeli.
—— striata.
Natica purpuroides.
Ostrea ungula.
—— Goldfussii.
—— arcuata.
Anomia striatula.
Plicatula liasina.
Ostrea semiplicata.
Pecten calvus.
—— textorius.
—— Thiollieri.
—— punctatissimus.
—— lunularis.
—— Lohbergensis.
Lima hettangiensis.
—— gigantea.
—— succincta.
—— pectinoides.
Limea Blakeana.
Monotis papyria.
—— inæquivalvis.
Gervillia Hagenovii.
Perna infraliassica.
Pinna Hartmanni.
Inoceramus pinnæformis.
Macrodon pullus.
—— naviculus.
—— hettangiensis.
Leda galathea.
—— Renevieri.
—— texturata.
—— subovalis.
Nucula navis.
Modiola Hillana.
—— Hillanoides.
—— lævis.
—— bifasciata.
Protocardium Philippianum.
Cardita Heberti.
Cardinia crassiuscula.
Cardinia concinna.
—— Listeri.
—— ——, var. hybrida.
Astarte obsoleta.
—— cingulata.
Tancredia ovata.
—— apicistria.
Lucina limbata.
Hippopodium ponderosum.
Myoconcha psilonoti.
Unicardium cardioides.
Gresslya galathea.
Pleuromya liasina.
—— crassa.
—— Dunkeri.
Pholodomya glabra.
Homomya ventricosa.
Goniomya heteropleura.
Spiriferina Walcotti.
Rhynchonella plicatissima.
Discina Holdeni.
Eryon, sp.
Ditrypa globiceps.
—— capitata.
—— quinquesulcata.
Serpula limax.
—— deflexa.
Galeolaria socialis.
Holothuria, sp.
Ophiura, sp.
Cidaris Edwardsi.
Pentacrinus psilonoti.
—— basaltiformis.
—— tuberculatus.
Montlivaltia Haimei.
—— Guettardi.
Bairdia liassica.
—— dispersa.
—— lacryma.
—— redcarensis.
—— elongata.
Cythere translucens.
—— triangulata.
—— paupercula.
—— arcæformis.
Polycope cerasia.
Coniferous wood.
Equisetites, sp.

CHAPTER IX.

ZONE OF AMMONITES OXYNOTUS.

All the beds of the Lower Lias above the *Bucklandi*-series as just described we include in the zone of *Ammonites oxynotus*. Like the former, they consist of a number of argillaceous beds but little distinct from each other or from others of the lower and basal portion of the Middle Lias. The top of each bed, in this case, is marked by an induration of calcareous matter, rendering the rock whiter in appearance and of a speckled or irregular aspect, with thinner or thicker branching, but broken, fucoid-like marks running in every direction. The bed is thus rendered gradually harder, it being very difficult to draw any line between this capping and the softer part below. It would seem possible that this is caused by the decay of some soft-bodied animals, just as the Gryphite-bands are formed from those with shells. Anyhow it is remarkable that the character of the surfaces of the various beds in the lower part of the Lias changes with the change of fauna contained in them. These remarks have reference to the section on the shore and in the cliffs of Robin Hood's Bay, where alone the *oxynotus*-beds can be satisfactorily seen. Inland they are but little exposed; being soft, they form no natural sections; and they have no economic importance—Boulder-clay or, at least, re-formed clay above them always being sufficient for brick-making in neighbourhoods where we might expect them. Where they are known, however, it is simply as dark blue clays with a few scattered nodules.

In the south of England the *oxynotus*-beds have a similar character, forming the greater part of what are called "Lias shales," while they are also called, from the prevalence in them of *Belemnites acutus*, the "Belemnite-beds." They have been divided by some geologists into three zones—those of *A. obtusus*, *A. oxynotus*, and *A. raricostatus* in ascending order, the latter including part at least of what we call the region of *Ammonites armatus* and include in the Middle Lias. In Yorkshire, however, as represented by Robin Hood's Bay, we do not find sufficient palæontological reasons for this separation. The Ammonites are, indeed, restricted, as the names of the above zones denote; but if other Ammonites were selected they might be divided differently, and no marked change in the accompanying fauna takes place. Indeed the characteristic of these beds is the poorness of their fauna; the zone contains fewer fossils, both in variety and number, than any other, considering its thickness, which at Bay Town amounts to 108 feet. An exception to this statement may perhaps be made in

the case of the Ammonites, remains of which in the various horizons are very common, and their varieties are numerous.

The *oxynotus*-beds commence as scars on the beach immediately opposite the descent from the village of Bay Town, the two long reefs which run out to sea, as seen at low tide, being the uppermost of them. As we proceed along the shore towards Peak they gradually rise, and we successively come upon lower beds, while the upper ascend into the cliff. They are there, however, covered by Boulder-clay and present no opportunities for study; but the lower and middle parts, are clear, and their thicknesses may be ascertained. They do not all reach the cliff, but the lowest beds remain permanently on the shore; after passing the gully of Stoupe Beck they reach the greatest elevation, and then gradually decline towards Peak till they meet the fault, where they are in contact on the shore with beds of the *margaritatus*-zone. The anticlinal therefore which has brought up the Lower Lias in this bay is best seen in following these beds; and by joining the point where they reach their greatest altitude, and that where the lowest beds of the *Bucklandi*-series are exposed, we may approximate to the direction of the axis of elevation, which is thus determined to be a little south of west, and to correspond with the line of elevation of the inland valleys. In the forcing-up of these beds, those nearer Peak were left to drag behind till they broke off and so dip downwards to the fault. The scars form a semicircle, as may be seen on the plan which we have drawn to illustrate the structure of this well-known shore. Their greatest dip is about 8°, in the centre; it gradually diminishes with the change of strike to 6° on either side.

The following is the detailed section of this zone; where the beds do not reach the cliff, or are covered when there, the thickness can only be estimated by the eye.

Section of oxynotus-*beds, Robin Hood's Bay.*

No.	Lithology.	Thickness. ft.	in.	Fossils.
1.	Indurated sandy band, with nodules of broken fossils.	*1	6(*e*)	*Belemnites.*
2.	Blue shale	8	6	
3.	Hardened band..................	0	3	*Pecten priscus, Belemnites, Cardinia hybrida, Gryphæa obliquata.*
4.	Blue shale	7	0(*e*)	*Homomya ventricosa.*
5.	Hardened band..................	0	3	
6.	Blue shale	4	0(*e*)	
7.	Blue shale with variable indurated bands, in places thick, elsewhere thin.	7	0	
8.	Hard band........................	0	4	
9.	Soft clayey band in places ...	0	3	
10.	Hard blue shales	2	6	
	Carried forward	31	7	

* *e*=estimated.

Section of oxynotus-*beds, Robin Hood's Bay (continued).*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Brought forward	31 7	
11.	Rubbly variegated hard band.	0 4	
12.	Blue breakable shales	2 10	*Lima pectinoides.*
13.	Rubbly variegated band	0 3	This and the next two bands run close together and make a feature in the cliff.
14.	Blue shale	0 10	
15.	Hard band......	0 2	
16.	Shale	1 0	*Nautilus striatus.*
17.	Hard band........................	0 3	
18.	Blue shales	3 7	*Pentacrinus tuberculatus.*
19.	Line of fossiliferous nodules.	0 3	*A. raricostatus, A. densinodus, Lima pectinoides, Pecten priscus, Monotis inæquivalvis.*
20.	Blue shales	1 8	*Pecten calvus, Lima pectinoides, Rhynchonella plicatissima.*
21.	Hard limestone band, with erect annelid (?) tubes.	0 8	*A. Simpsoni, Nautilus striatus.*
	Parting of shale	2–4 in.	*Gryphæa obliquata, Homomya ventricosa.*
22.	Hard limestone band*	8–6 in.	
23.	Blue shale, crumbly	1 3	*A. gagateus, Lima pectinoides, Modiola lævis, Cardinia hybrida.*
24.	Hard rubbly stone	0 4	
25.	Blue crumbly shales with bands of scattered irregular doggers.	5 8	*Bel. acutus, Pecten calvus, Protocardium oxynoti, A. gagateus, A. oxynotus.*
26.	Marly stone in the form of doggers with *Pentacrinus*-band and cone-in-cone structure below.	0 2	*Pent. tuberculatus, Actæonina fragilis, Hydrobia solidula, Lima pectinoides, Leda.*
27.	Shales with many scattered sandstone doggers, shell-layer towards base.	5 10	*A. planicostatus, Lima pectinoides, Cardinia hybrida, Gryphæa obliquata.*
28.	Hardened band..................	0 5	
29.	Soft shale	1 7	
30.	Whitened calcareous band ..	0 3	
31.	Variable blue-black shales with scattered doggers (flat)	14 0	*Pent. tuberculatus.*
32.	Thin whitened band............	0 2	
33.	Shales.............................	1 4	*Am. sagittarius, Bel. acutus.*
34.	Whitened band..................	8–12 in.	*Ostrea arcuata, Bel. acutus.*
35.	Shales.............................	5 0	*Am. sagittarius, Pent. tuberculatus.*
36.	Harder whitened band.........	0 9	
37.	Shale	2 3	*Am. sagittarius, Bel. acutus, Ostrea arcuata.*
38.	Thick whitened band	1 8	
39.	Blue shale, unseen in cliff, with line of crustacean nodules.	6 0 (e)	*Am. planicostatus, A. obtusus, A. sagittarius, Am. stellaris, Hippopodium ponderosum.*
	Carried forward	91 8	

* This double band is a very good mark for a base-line of measurements; it is traceable through the whole section, and comes up to the cliff on either side of Mill Beck.

Section of oxynotus-*beds, Robin Hood's Bay (continued).*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Brought forward	91 8	
40.	Hard brown limestone band forming a strong scar.	0 5	
41.	Hard blue shale with line of scattered doggers, 3 ft. down	8 0(*e*)	*Pecten priscus, Bel. acutus, Ostrea arcuata, Pentacrinus tuberculatus.*
42.	Hard calcareous rubbly stone forming a *very* strong continuous scar*.	1 3	
43.	Blue shale with beds of oysters	2 4	*Ostrea arcuata, Pentacrinus tuberculatus, Pecten priscus.*
44.	Indurated limestone band* ...	4–6 in.	*Ostrea arcuata, Cardinia hybrida, Hippopodium ponderosum*
45.	Blue soft and smooth shale with round nodules.	3 6(*e*)	*Am. planicosta.*
46.	Indurated calcareo-argillaceous rubbly band, speckled brownish.	0 2	
	Total thickness	107 10	

The last four of these beds only doubfully belong to this zone; they are lithologically more connected with the zone below, but are placed here on account of the occurrence of *A. planicostatus.*

It is thus seen that the whole series presents considerable uniformity, the only lithological features being the double hard band near the top (44 feet down), and the two single limestones near the base. The series of beds is interesting from its similarity to that of the *Bucklandi*-beds below. The conditions of deposit, though varying from time to time, as evidenced by the harder calcareous portions of the beds, have varied continuously; and, apart from the evidence of fossils, no marked line could be anywhere drawn, though the extremes of the whole series are sufficiently distinct.

Other Exposures of the *oxynotus*-beds.

These beds are known elsewhere at two distant localities in the northern area, and have been recognized at three places in the south.

Redcar.—In the bay, between the Redcar and Coatham Scars, are a series of rocky ridges, striking parallel with the Redcar Scars, exposed only at the low spring tides; these are called High Stone, and consist of two principal reefs. The eastern one is made by a bluish grey, friable, micaceous, argillaceous, arenaceous limestone, and contains *Ammonites oxynotus* and some other mollusca given in the subjoined table; the western one is constituted of friable micaceous sandy shales of the region of *Ammonites armatus.*

Ayton.—In the Back Lane, on the north side of High Green in Ayton, there are exposed blue micaceous shales; and in the course of

* This forms a second good line of demarkation.

the river Seven, below the sluice, there are to be seen similar shales containing a thin blue limestone, which have yielded *Ammonites gagateus*, *Cardium oxynoti*, and *Lima pectinoides*.

Some of the characteristic Ammonites of the upper part of the Lower Lias, such as *A. gagateus* and *A. stellaris*, are occasionally found among the beach-stones in Marske Bay, probably derived from submerged beds of the *oxynotus*-zone, which must crop out seaward between Marske and Saltburn.

Warter.—At this village the Chalk overlaps this portion of the Lias; and the drains and well-sinkings show dark blue-black shale soon rotting to clay, containing *A. gagateus* and *B. acutus*.

Londesborough.—On the fields adjoining the Market-Weighton road have been found nodules with *A. densinodus* (young) similar to those found at Robin Hood's Bay.

Market Weighton.—In the railway-cutting before mentioned, farther east than where the *angulatus*-beds are seen, the soft blue clays which are here and there exposed contain nodules with *A. oxynotus*, *A. gagateus*, *A. densinodus*, *B. acutus*, and shell masses yielding *Protocardium oxynoti*, *Lima pectinoides*, *Cardinia hybrida*, *Gryphæa obliquata*, *Pecten*, *Monotis inæquivalvis*. These clays have yielded some very finely grown Foraminifera.

Blocks of a shell limestone, densely packed with *Ammonites raricostatus*, as also specimens of *Gryphæa arcuata*, have been collected from the Boulder-clay in many localities; indeed the finest specimens of the above-named Ammonite are all obtained from such sources, being very rare *in situ*.

PALÆONTOLOGY.

The total number of species recorded from this zone amounts only to sixty-five, strongly contrasting with the rich fauna of the *Bucklandi*-beds, more particularly so if the relative frequency of occurrence be noted. Excepting the Ammonites, which are restricted species, a very few shells are at all diffused or numerically strong; such are *Belemnites acutus*, *Cardinia hybrida*, *Homomya ventricosa*, *Pentacrinus tuberculatus*, *Cardium oxynoti*, and *Gryphæa obliquata*. The remainder of the species quoted in the subjoined list are either individually rare or, if abundant, have a limited vertical distribution; the Lower-Lias types are obviously on the wane: the *Homomya*, *Belemnites*, *Cardinia*, and *Pentacrinus* are the only forms which here attain to their maximum development; whilst a few others recur in the Middle Lias to regain their pristine abundance—such are *Avicula inæquivalvis* and *Hippopodium ponderosum*.

The fauna consists (in addition to the *Bucklandi*-species) of several restricted species, a few common forms relatively abundant, which have just been mentioned, and of a few preeminently Middle-Lias fossils, but which are encountered only on the confines of the two formations.

The following appear to be peculiar—the *Ammonites*, *Belemnites dens*, *Trochus robigus*, *Hydrobia solidula*, *Leda Heberti*, *Gryphæa cymbium*, var. *obliquata*, and *Glyphæa lyrica*. The *Hydrobia* and the *Leda* occur elsewhere in lower beds of the Lias.

The Ammonites are restricted as follows :—*A. raricostatus* occurs only above the double hard band No 21 & 22 in the section. *A. densinodus* is plentiful in a band about 2 feet above it; almost every nodule contains specimens associated with *Pecten priscus*. *A. oxynotus* and its allied *A. Simpsoni* are restricted to a range of from 6 feet above the double hard band to 8 feet below it; *A. denotatus* characterizes the shales for some distance below this band; *A. gagateus* is chiefly found in a line of nodules 8 feet below it; *A. planicostatus* is confined to the lower half, where it is everywhere met with; and *A. sagittarius* begins about 20 feet above the base and ascends as high as *A. planicostatus*; *A. obtusus* and *A. stellaris* are chiefly found a little above the upper of the two single limestones, the former being plentiful. The limitation of the range of the Ammonites is thus more marked in this than in any other zone.

List of fossils of the oxynotus-*beds.*

Ichthyosaurus intermedius.
Ammonites caprotinus.
—— Collenoti.
—— impendens.
—— densinodus.
—— gagateus.
—— difformis.
—— obtusus.
—— oxynotus.
—— planicostatus.
—— raricostatus.
—— sagittarius.
—— Greenoughi.
—— Simpsoni.
—— stellaris.
—— spiratissimus.
—— semicostatus.
—— ophioides.
—— viticola.
—— Oppeli.
Nautilus intermedius.
Belemnites acutus.
—— infundibulum.
—— calcar.
—— dens.
—— penicillatus.
Actæonina fragilis.
Trochus robigus.
Cerithium gratum.
Turritella Dunkeri.
—— regularis.
Hydrobia solidula.
Gryphæa arcuata.
Gryphæa obliquata.
Ostrea Goldfussii.
Pecten priscus.
—— æqualis.
—— calvus.
Lima gigantea (?) junior.
—— pectinoides.
Monotis inæquivalvis.
Pinna folium.
—— Hartmanni.
Leda Heberti.
—— subovalis.
—— galathea.
Cucullæa Münsteri.
Modiola scalprum.
Protocardium oxynoti.
Astarte obsoleta.
Nucula navis.
Hippopodium ponderosum.
Cardinia Listeri, var. hybrida.
Unicardium cardioides.
Gresslya galathea.
Homomya ventricosa.
Arcomya vetusta (juvenissima).
Rhynchonella plicatissima.
Cythere translucens.
Glyphæa lyrica.
Eryma lævis.
Ditrypa quinquesulcata.
—— circinata.
Pentacrinus tuberculatus.
—— basaltiformis.

CHAPTER X.

ZONE OF AMMONITES JAMESONI.

The beds which compose this zone are a series of argillaceous shales varying in hardness and smoothness, but all of them more or less micaceous, though in a small degree; and some are sandy. They are separated into beds by rows or layers of ferro-argillaceous limestone, bluish-brown within and weathering red, which maintain their level with considerable constancy; these bands are highly characteristic of the Middle Lias, and are known locally by the name of "doggers;" similar masses occur in the Upper Lias, but without iron, except in the form of pyrites. The *Jamesoni*-beds also contain pyritous bands, which are highly fossiliferous; and beneath some of the doggers cone-in-cone structure is developed. The whole series has an aspect of great uniformity; and its interest is chiefly palæontological, though inland the lower portion is worked for bricks. This zone may be separated into two parts:—the upper that of *A. Jamesoni* proper; and the lower the subzone of *A. armatus*, which contains a fauna of great interest from its sudden exhibition of medio-liassic forms in contradistinction to the barrenness of the uppermost beds of the Lower Lias. The zone of *A. Jamesoni* has been attached to the latter division by Phillips and others; but an examination of the fauna which we record can leave no doubt that the line between the two divisions of the Lias must be drawn below these beds. In some parts of England and Germany the horizon of *A. Henleyi*, which is situated at the top of the *Jamesoni*-beds, is characterized by a considerable number of Ammonites, and by Oppel was raised to the rank of a zone, that of *A. ibex*, and designated by Brauns that of *A. centaurus*. In Yorkshire, though the dominant Ammonite *A. Henleyi* occupies the same relative position as it does elsewhere, yet, as it is unaccompanied by any other restricted fossils, we include it in the *Jamesoni*-beds.

Beds of this age are characterized by the great variety of Belemnites, both as regards number of individuals and species, and from this circumstance have been named the "Belemnite-beds" by many French and German writers, a name also given to the zone of *A. oxynotus* from the abundance of *B. acutus*. The Yorkshire equivalents preeminently deserve this appellation. In Swabia, they are known as the "*numismalis*-marls" because of the prevalence of *Waldheimia numismalis*, a ubiquitous species, though absent in the Yorkshire series of these beds.

There is only one section in which we can obtain by measurement their full thickness; and that is at the north side of Robin Hood's

Bay, the base being just below the New Inn. On the south side, at Peak, they are fully exposed in the cliff on the west of the fault, but are inaccessible; and the base of them nowhere else along the coast rises above the sea. The section in Robin Hood's Bay, where they show a total thickness of 225 feet, is as follows:—

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Shale	4 5	*A. capricornus.*
	Dogger	5–10in.	
	Base of *capricornus*-beds.		
1.	Light hard crumbly shale	5 0	
2.	Dogger	0 6	
3.	Shale	10 0	
4.	Irregular dogger.		
5.	Shale	4 0	
6.	Brown sandy layer	0 3	
7.	Shale	5 3	
8.	Variable dogger	2 6	
9.	Shale with indurated bands and nodules.	13 6	*A. Henleyi, A. fimbriatus. Ophioderma Gaveyi.*
10.	Scattered dogger-band	0–12 in.	
11.	Shale	2 9	
12.	Dogger	0 3	
13.	Hard crumbly shale	13 0	*Belemnites elegans.*
14.	Dogger	0 6	
15.	Bluer shale	2 0	
16.	Irregular dogger.		
17.	Bluer shale	7 0	*A. brevispina, Gryphæa obliquata, Modiola scalprum, Pleuromya ovata.*
18.	Well-marked dogger	0 3	*Belemnites araris, B. elegans, Monotis inæquivalvis.*
19.	Hard grey indurated shale with more indurated band in the middle.	11 6	*Limea acuticosta, Pecten æquivalvis, Pinna folium,* wood.
20.	Dogger	0 3	
21.	Blue shale	2 4	
22.	Dogger	0 4	
23.	Blue shale	5 0	*Gryphæa obliquata, A. brevispina.*
24.	Dogger	0 3	
25.	Shale	1 10	*Pecten priscus, Chemnitzia Blainvillei.*
26.	Regular dogger	0 6	
27.	Shale	3 10	*Gresslya striata, Leda galathea, Plicatula spinosa, Pinna folium, Belemnites araris. B. virgatus.*
28.	Irregular dogger	0 6	
29.	Shale	3 0	*A. brevispina, A. polymorphus, Ditrypa circinata.*
30.	Dogger	0 5	
31.	Shale	1 0	
	Carried forward	98 2	

No.	Lithology.	Thickness ft.	in.	Fossils.
	Brought forward	98	2	
32.	Dogger	0	5	*Modiola scalprum.*
33.	Shale	14	8	*Am. lynx, A. polymorphus, Pholadomya decorata* (vertical). *Pecten priscus, Pleuromya ovata.*
34.	Dogger	0	6	*Phol. decorata* (vertical).
35.	Shale	5	4	*Pholadomya decorata.*
36.	Irregular dogger.			
37.	Shale	4	3	*Pecten priscus, Lima Hermanni.*
38.	Irregular dogger.			
39.	Shale	5	3	*Unicardium cardioides.*
40.	Irregular dogger.			
41.	Shale	3	0	*Rhynchonella plicatissima, Arcomya elongata, Ditrypa circinata, Pinna folium.*
42.	Irregular dogger.			
43.	Shale	4	0	*Pecten priscus, Gryphæa obliquata, Gresslya ovata,* Crustacean.
44.	Strong dogger	0	8	*Pinna folium.*
	Base of *Jamesoni*-beds proper.			
45.	Blue shale	10	0	*Pinna folium, Cucullæa Münsteri, Limea acuticosta, Arcomya vetusta, Glyphæa Terquemi, Lima Hermanni.*
46.	Ironstone dogger	0	8	
47.	Blue shale, with pyritous nests, full of fossils about 5 feet down*.	15	8	*Lima Hermanni, Monotis inæquivalvis, Gryphæa obliquata, Waldheimia sarthacensis, Pecten priscus, Pinna folium, Spiriferina Walcotti,* var., *Pleurotomaria procera, Rhynchonella plicatissima, Protocardium oxynoti, Cucullæa Münsteri, Trigonia* sp., *Nucula cordata, Ammonites armatus, A. Taylori, Belemnites, Gresslya ovata, G. striata.*
48.	Dogger	0	4	
49.	Blue shale	12	0	
50.	Band of rotted clay	0	2	
51.	Ironstone dogger well marked in cliff.	0	3	*Inocer. ventricosus, Pecten calvus, Chemnitzia Blainvillei.*
52.	Blue shale	5	0	
53.	Strong ironstone dogger	0	4	*Gryphæa obliquata.*
54.	Blue shale, with doggers and nests of fossils scattered.	24	0	*Ditrypa circinata, A. armatus, Pecten priscus, Belemnites.*
	Carried forward...........	204	8	

* Is at the base of the cliff, making the point to the south, of the north cheek of the bay.

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Brought forward	204 8	
	Thin line of broken fossils ...	0 1	*Belemnites, Pecten priscus, Cerithium, Rhynchonella variabilis,* Ammonites of small size.
55.	Blue shale full of Belemnites and Gryphæas.	5 6	*Ammonites armatus, Belemnites, Rhyn. tetrahedra, Am. planicosta, Gryphæa obliquata, Anomia numismalis, Leda subovalis, Limea acuticosta, Pecten priscus, Cucullæa Muensteri, Pinna folium.*
56.	Ironstone dogger	0 3	
57.	Blue shale	3 0	*Ammonites tubellus, A. armatus.*
58.	Scattered irregular doggers, and blue shale.	3 0	*Ammonites tardecrescens, Pecten substriatus, P. calvus, Cucullæa Muensteri.*
59.	Argillaceous ironstone dogger with cone-in-cone structure at the top.	0 4	
60.	Blue shale.........estimated at (a few inches only seen in the cliff).	8 6	*Limea acuticosta, Pentacrinus, Ammonites Macdonnelli, A. tubellus, Belemnites elegans.*
	Base of the zone of *A. armatus*		
	Total thickness.........	225 4	
	Indurated band of sandy shale	1 6	
	Softer arenaceous shale	8 6	

Subzone of Jamesoni *proper*.—The fossils of this subzone lie in general in the shale or in hardened portions of it: when they occur, it is generally in nests, or perhaps layers, much of the rock being composed of broken remains whose decomposition has rendered it hard; the common fossils in these are Belemnites, Pectens, and Gryphæas; and these assemblages are perhaps the most characteristic feature of the zone, as they are of the same horizon in Lincolnshire. The dogger bands are not eminently fossiliferous, but only in proportion to their thickness. They are more earthy than those of the *spinatus*- and *margaritatus*-beds. The most fossiliferous do not lie in the regular lines, but separately between them: some such doggers contain nothing but *Limea acuticosta*; others envelop specimens of *Ammonites striatus*. The characteristic Ammonites, which are always badly preserved, lie, like the rest, in the shale, generally in definite lines, as do also the *Pholadomyæ*, which occur in their natural position, siphonal end upwards. All the beds above enumerated, besides occurring in the cliff, where they have been measured, are also spread out upon the scar; and many of them running parallel to the cliff and dipping at a low angle, expose long strips, some as long as a quarter of a mile, to surface examination; but notwithstanding this, the variety of

fossils we have been able to discover on these scars is comparatively little. We may thus perhaps connect uniformity of lithological feature with paucity of organic forms: there being no change of condition, no alteration took place in the fauna.

Other Exposures of *Jamesoni*-beds.

Peak.—As before mentioned, these beds come down again on the other side of the Robin Hood's Bay anticlinal, to meet the fault. At the point where the fault cuts the cliff, 350 feet above the sea, the beds exposed are the sandstones of the *margaritatus*-zone; and at the base of the cliff we are at the bottom of the *armatus*-zone; so that this 350 feet includes the thickness of three zones (*armatus*, *Jamesoni*, and *capricornus*), besides a portion of the zone above. What proportions here to assign to each it is impossible to say; but on comparing the total thickness with that on the north side, it is plain that none of them can be much deteriorated.

Boulby or Rock-cliff.—Proceeding along the coast from Staithes, the Scars opposite the hamlet of Boulby, which consist of shale and dogger bands, are conspicuous from the contained *Ammonites fimbriatus* of large size, and approximately mark the upper limit of the *Jamesoni*-beds. The strata rise to the northward; but the interposition of an extensive talus prevents the band with *A. fimbriatus* being traced by the eye up into the cliff under Boulby Alum-works, in the precipitous face of which we have not been successful in identifying it. Yet there is good reason for the statement that the lower 25 feet of this cliff consists of beds of the *Jamesoni*-zone: *A. Jamesoni* is abundant in the lower 12 feet of the cliff; and fallen masses of shale from considerably higher contain *A. Henleyi* and *A. fimbriatus*.

Here, as at Robin Hood's Bay, the *Jamesoni*-beds consist of shale with doggers, and layers of shells, often, however, associated with some considerable portion of sand, which in conjunction with the calcareous matters form indurated bands up to 8 or 9 inches of thickness.

Between the Boulby and Lofthouse alum-works these strata attain their greatest elevation, having been brought into view by an anticlinal which courses S.E. from this point; but they decline towards the west, and leave the cliff before Hummersea is reached, not again to be seen at the surface till Huntcliff is gained.

Huntcliff.—At about half a mile north of Skinningrove we encounter scars on the half-tidal way which contain nodules enclosing *A. fimbriatus*. This portion of the section rises into the cliff under the highest point of Huntcliff, but, after coursing along the north front of it, declines to the sea-level at the western extremity, near Saltburn. The *Jamesoni*-beds, which underlie the limited thickness of shales containing *A. fimbriatus*, thus constitute the base of this imposing sea-cliff, and spread out as extensive weed-covered flats between tidal marks. The characteristic Ammonite attains to

an elevation of 9 feet in the cliff; but many of the commonly associated species ascend much higher, as seen in the following section:—

Section of Jamesoni-*beds, Huntcliff.*

	ft.	in.
Hard shale in large blocks.		
Shale breaking in small pieces	20	0
Blue shale crumbling, *Belemnites elegans, Pecten lunularis*	7	0
Limestone dogger	0	4
Blue shale	7	3
Assumed base of the *capricornus*-beds.		
Double rows of doggers, *Gresslya ovata, Lima eucharis*	1	6
Blue shale, *Belemnites charmouthensis*	10	3
Round doggers	0	3
Shale	7	8
Dogger band	0	5
Shale	3	6
Dogger	0	4
Shale with shell-bed, *Belemnites elegans, Pinna folium, Plicatula spinosa*	2	8
Dogger	0	4
Shale	2	9
Dogger	0	2¼
Shale, *Belemnites charmouthensis, Gryphæa obliquata*	5	2
Dogger	0	4
Shale, *Belemnites, Pecten æquivalvis, Modiola scalprum, Gryphæa obliquata, Rhynchonella tetrahedra*	1	11
Flattened doggers, *Unicardium cardioides, Pholadomya decorata*	0	4
Shale with scattered doggers, *Pinna folium, Hippopodium ponderosum*	5	7
Flattened doggers.		
Shale with scattered doggers, small elliptical oval concretions enclosing Crustacean débris and shell masses, *Ammonites Jamesoni*, and many other characteristic fossils	8	8
Flattened doggers, *Belemnites*	0	4½
Shale to foot of cliff	4	0
Shales and doggers to low-water mark, with *Am. Jamesoni, A. brevispina, A. polymorphus*, &c., estimated (from breadth of surface and dip of 2¼ degrees) at	30	0
Total thickness	86	3

A similar section measured at another part of the cliff is given at page 92.

The flat scars under Huntcliff present a scene of the wildest confusion, being encumbered with huge blocks of the Middle Lias sandstones fallen from the cliff above; conspicuous amongst them, and especially towards the high-water mark, are hummocks of shale crowned with a shelly indurated layer, which thus has partially preserved the underlying softer mass from the mechanical wear of the waves, and the destructive effects of alternate saturation with water and desiccation by the sun's heat.

Fossils occur in great profusion in these layers, but may also be collected in excellent preservation from the surface of the shales at high-water mark.

Coatham Scars.—The *armatus*-beds which constitute the western ridges of High Stone, Redcar Bay, are not seen underlying the shales with *A. Jamesoni*, which make the broad expanse of the landward side of the Coatham Scars; but the point where our section begins cannot be vertically many feet in thickness above them. The Coatham Pier intersects the line of strike of the beds on that part of the scars at 6° from a right angle, which is nearly due east and west. Column No. 19 of the pier stands upon the most southern exposure of rock. We assign to the *Jamesoni*-beds a breadth of outcrop of 630 feet, which, dipping at 11° north, corresponds to a thickness of 120 feet. The shales are identical with those described in the other sections of these beds; but the thin blue argillaceous limestone courses have not been noticed elsewhere.

It is only during the hottest part of the summer that these scars can be at all examined in a satisfactory manner, as at other times of the year they are overgrown with seaweed and incrusted with parasitic life.

Ormesby.—A well-sinking at Long-Bank Farm, and the driving of a water-level for the mines adjacent, disclosed the presence of the *Jamesoni* shales beneath the Boulder-clay in this district, and helped to determine the direction and amount of throw of the fault which bounds the Normandy Mines on the north-west. Numerous fossils were obtained from the two excavations, including *Ammonites brevispina, Pinna folium,* and other restricted species of this zone.

Upsall.—The Goodwood-Pit sinking in Osborne Rush Plantation on the south side of Barnaby Moor finished off in these shales at a depth of 240 feet. The spoil-heap consists of blue micaceous shale crumbling to a semi-clay; russet-coloured clay ironstone doggers, dark-brown, and of an earthy texture inside, abound; some few blue argillaceous limestone doggers weathering white occur. The nucleus of a *Pinna folium* was of clay ironstone. The fossils of the limestone and shale, and the lithological characters, all bespeak the horizon of *Ammonites Jamesoni.* This determination is of value in calculating the throw of the Upsall fault, which passes a little to the north of the pit, between it and the Oolitic escarpment.

Pinchinthorpe to Easby.—The north end of the plateau of Middle Lias of Bonsdale Hill, Pinchinthorpe, is based on sandy micaceous shales with some doggers which belong to this or the succeeding horizon. Similar beds are disclosed on the north-west slope of Roseberry, and along the line of the Whin Dyke at Langbarugh; but in the Wood-End railway-cutting we have indisputable evidence of this horizon at the surface. Here, as in the case of the conjectural exposures, the strata are blue micaceous shales with ferro-calcareous doggers, but with numerous characteristic specimens of the zone of *Ammonites Jamesoni*, including *Am. polymorphus, Pinna folium, Plicatula spinosa*, &c.

Easby.—At the mill-dam across the river Leven at Easby there are exposed blue micaceous shales with large limestone doggers, the shales being traceable down the stream as far as the mill. A very

large number of *Jamesoni* fossils were collected in the shales and doggers, including the ubiquitous Ammonite species *A. Jamesoni* and *A. polymorphus.*

Halliday Slack, on the front of Chigley Moor.—This section reaches probably to this level; but no fossils have been observed in the lower part.

Husthwaite.—In the little tongue of Lias which runs up towards Coxwold, between two Oolite regions, various zones are here and there exposed. The lowest, by stratigraphical considerations, is in the cutting west of Husthwaite gate, where are numerous beds of blue shale and doggers, all grass-covered; from fragments extracted containing small specimens of *Limea acuticosta* and *Protocardium oxynoti* &c., it is judged that these may be *Jamesoni*-beds, as from their position they could not well be lower.

Easingwold.—The lower portions of this town lie upon blue clays; and having obtained, on the occasion of a drain being made, the following fossils, *Cardium oxynoti, Pleuromya* sp. *Belemnites araris, Rhynchonella variabilis, Cucullæa Münsteri, Arca* sp., *Ostrea* sp., *Chemnitzia Blainvillei,* with marls and sulphurous nodules, we think it probable that these are the lower part of the *Jamesoni*-beds, verging on *armatus.*

Lower Mowthorpe.—This is a farm on the southern escarpment of the Oolite to the north of Bulmer. Here on the side of a small beck is a low cliff of rotten blue brown-weathering shale, in which occurred *Pecten æquivalvis* (small) and *Ditrypa* sp.; and being but little above the level at which, in a neighbouring beck, *armatus*-nodules occurred, it probably belongs to the zone under consideration. Shales which might belong to this zone occur beneath the Oolite N.N.E. of the village of Foston; and they probably do so belong if we have interpreted rightly the structure of the country here; but they are too little exposed, in stream-sides, to give much information themselves. No more Middle Lias is seen till we reach the neighbourhood of Kirby Underdale, Garrowby. In the localities which will be indicated for *armatus*-beds, there appears to be a greater thickness than they require, and it is therefore probable that beds of the present subzone are also uncovered; no signs, however, of them occur anywhere farther to the south; and from the proximity of the *spinatus*-beds to those of *A. oxynotus* near Market Weighton it is most likely that they have thinned out, or are insignificant.

In the valleys.—Only one of these, Bilsdale, is excavated to sufficient depth to expose this zone. In Bilsdale, along the south bank of Raisdale Beck, which crosses the high road just south of Chopgate, are several low cliffs, of blue brown-weathering micaceous shales with bands of limestone doggers, very similar in appearance to those in Robin Hood's Bay. The occurrence in them of *Pholadomya decorata, Pinna folium,* and *Trochus thetis* proves them to be *Jamesoni*-beds, as is also evident from our ability to trace up the whole series in the sides of a rugged road above leading to some-jet works, from the *capricornus*- to the *spinatus*-zone.

Subzone of Ammonites armatus.—The same strata as given in the

typical section come down again on the S.E. side of Robin Hood's Bay; but here they are not so easy to examine, as they rise quickly, and the scars are covered with weed; they are the highest beds exposed on the shore on the downthrow side of the Peak fault.

The only other locality along the northern escarpment where beds of this age are recognized with any degree of certainty, is the High Stone in Redcar Bay, already referred to on p. 84. The westernmost scar consists of friable, micaceous, sandy shales, containing *Am. armatus*, *Pholadomya decorata*, *Gresslya ovata*, and a few other species.

We venture to refer to this horizon the strata exposed to view alongside the Whin Dyke at Staple-Hole Quarry, Langbarugh. In a crosscut to the quarry there may be seen about 20 feet of sandy micaceous shales, with scattered nodules of a black semicrystalline limestone (possibly phosphatic). The fossils are somewhat obscure, on account of the induration by igneous action; but the following have been satisfactorily determined—*Pecten calvus*, *P. æquivalvis*, *Modiola numismalis*, *Leda galathea*, *Astarte striato-sulcata*, *Lingula sacculus*.

When in the southern area the higher beds of the Lias gradually begin to emerge from beneath the great overlap of the Oolite and Chalk, these are the first brought into view. The shales at the base of the hill at Kirby Underdale, which is capped by an Oolitic outlier, enclose nodules similar to those of the *armatus*-beds, and contain *Chemnitzia Blainvillei*, *Modiola numismalis*, *Pecten Hehlii*, *Rhynchonella furcillata*, which is at least consistent with their belonging to this zone. Similar nodules of a light-blue interior occur in many of the streams, especially near Garrowby Hall, where *Pinna foliun* is met with. At Bugdale spring, in the Park, where the water escapes from beneath the chalk, the nodules of the Lias are of the same character and contain *Waldheimia sarthacensis*, which is common in this and the overlying subzone, thus deciding the horizons of the other localities mentioned. Along the hill-side between Bishop Wilton and Garrowby similar nodules are to be seen, in one of which *Am. armatus* occurred. The only other locality where beds of this age are known is in a brickfield belonging to Lord Muncaster, about a mile from Warter, towards Pocklington. Here the beds are thrown up on their edges, dipping at the surface at a high angle to the W., as far as they can be said to dip at all when so disturbed. The stratification is almost lost, though there are rows of large doggers, some of which are unfosiliferous; but every one of a certain set lying about 6 feet below the highest beds exposed contains one or more specimens of *Am. armatus* or *A. Macdonnellii* with smaller fossils surrounding them. The clays of the series are remarkable for containing a very large quantity of crystals of selenite, some of large size. On the other side of the pit are beds of the *Bucklandi*-zone; but the intervening space affords no opportunity for observation of the intermediate zones.

Palæontology.

The two subzones are closely united together by the occurrence of numerous common species, many of which pass onwards to the higher zones; but they have a distinct series of Ammonites, agreeing in this respect with the subzones of *raricostatus*, *oxynotus*, and *obtusus* in the zone below. The species which are peculiar to the zone, but common to both its divisions, are the following—*Ammonites polymorphus*, *Belemnites elegans*, *B. charmouthensis*, *B. virgatus*, *B. araris*, *Pholadomya decorata*, *Gresslya striata*, *Rhynchonella furcillata*, *R. rimosa*, *Leda Zieteni*, *Pinna folium*.

Those that are known only in the *armatus*-beds are (besides the Ammonites) *Belemnites palliatus*, *Cerithium Slatteri*, *Chemnitzia Youngi*, *Pleurotomaria procera*, *Arcomya vetusta*, *Glyphæa Terquemi*, *Trigonia modesta*, *Spiriferina Walcotti*, var. *verrucosa*.

Those peculiar to the *Jamesoni*-zone proper are *Cerithium camertonensis*, *Trochus thetis*, *Turbo littorinæformis*, *Cardinia attenuata*, *Macrodon pulchellus*, *Arca Stricklandi*, *Spiriferina oxyptera*, *Rhynchonella subconcinna*, *Arcomya elongata*, *Ophioderma Gaveyi*, *Pseudoglyphæa hamifera*.

The greater number of these are of great rarity, whereas those which unite the two subzones are common.

Fossils of the zone of Ammonites Jamesoni.

J signifies the subzone of *Jamesoni* proper; A signifies the subzone of *armatus*.

Plesiosaurus, sp. (J.)
Ammonites Jamesoni. (J.)
—— brevispina. (J.)
—— Henleyi. (J.)
—— polymorphus. (J, A.)
—— lynx. (J.)
—— Huntoni. (J.)
—— Loscombi. (J.)
—— Regnardi. (J.)
—— fimbriatus. (J.)
—— striatus. (J.)
—— armatus. (A.)
—— aculeatus. (A.)
—— socialis. (A.)
—— validus. (A.)
—— Grenouillouxi. (A.)
—— Taylori. (A.)
—— Heberti. (A.)
—— tubellus. (A.)
—— Macdonnellii. (A.)
—— tardecrescens. (A.)
Nautilus araris. (A.)
Belemnites elegans. (A.)
—— charmouthensis. (J, A.)
—— araris. (J, A.)
—— virgatus. (J, A.)
—— palliatus. (J, A.)
—— clavatus. (J.)
—— apicicurvatus. (J.)
Actæon marginatus. (J, A.)
Cerithium Slatteri. (J, A.)
Chemnitzia faveolata. (J.)
—— carusensis. (J, A.)
—— Blainvillei. (J, A.)
—— undulata. (J, A.)
—— Youngi. (A.)
Trochus thetis. (J.)
Eucyclus imbricatus. (J, A.)
—— Gaudryanus. (J.)
Turbo littorinæformis. (J.)
Pleurotomaria procera. (A.)
Protocardium oxynoti.
—— truncatum. (J.)
Unicardium cardioides. (J, A.)
Astarte striato-sulcata. (J, A.)
Cypricardia cucullata. (J.)
Hippopodium ponderosum. (J, A.)
Cardinia attenuata. (J.)
Cardita multicostata. (J.)
Saxicava, sp. (A.)
Pholadomya decorata. (J, A.)
Pleuromya punctata. (J.)
—— ovata. (J, A.)
Gresslya striata. (J.)
Arcomya elongata. (J.)
—— vetusta. (A.)
Goniomya hybrida. (J.)
Trigonia modesta. (A.)

Leda Zieteni. (J, A.)
—— Galathea. (J, A.)
—— complanata. (J.)
—— minor. (A.)
—— subovalis. (A.)
Nucula cordata. (J, A.)
Cucullæa Münsteri. (J, A.)
Macrodon pulchellus. (J.)
Arca Stricklandi. (J, A.)
Modiola scalprum. (J, A.)
—— numismalis. (J, A.)
Pinna folium. (J, A.)
Inoceramus ventricosus. (A.)
Gervillia ærosa. (J, A.)
Monotis inæquivalvis. (J, A.)
Plicatula spinosa. (J.)
Lima Hermanni. (J, A.)
—— pectinoides. (J.)
—— eucharis. (J.)
Limea acuticosta. (J, A.)
Pecten priscus. (J, A.)
—— æquivalvis. (J, A.)
—— substriatus. (J. A.)
—— calvus. (J, A.)
—— lunularis. (J.)
Anomia numismalis. (J, A.)
Gryphæa obliquata. (J, A.)
Ostrea lageniformis. (J.)
Waldheimia sarthacensis. (J, A.)
Spiriferina Walcotti (var.). (A.)
—— oxyptera. (J.)
—— rostrata. (J, A.)
Rhynchonella tetrahedra. (J, A.)
—— variabilis. (J, A.)
—— furcillata. (J, A.)
—— plicatissima. (J, A.)
—— calcicosta. (A.)
—— rimosa. (J, A.)
—— subconcinna. (J.)
Lingula saccula. (J.)
Leptæna belemnitica. (J.)
Ditrypa circinata. (J, A.)
—— capitata. (J.)
—— 5-sulcata. (J.)
Serpula plicatilis. (J.)
—— flaccida. (A.)
Glyphæa Terquemi. (A.)
Pseudoglyphæa hamifera. (J.)
Ophioderma Gaveyi. (J.)
Hemipedina, sp. (J.)
Pseudodiadema, sp. (J.)
Pentacrinus Millerii. (J, A.)
—— scalaris. (A.)

CHAPTER XI.

ZONE OF AMMONITES CAPRICORNUS.

General Characters.—The beds comprised under this zone are essentially argillaceous and offer sufficiently distinctive characters to justify us in detaching them from the *Jamesoni*-shales upon which they lie. These, we have seen, split into thin laminæ, are smooth and fine-grained, while the main mass of the *capricornus*-shales have a coarse, earthy, dull aspect, a mixed colour of black and grey, and break up into rough irregular pieces. In general they are more or less sandy and micaceous, and sometimes they contain so much carbonate of lime as to readily effervesce with acid. Towards the upper part of the series the argillaceous matter is indurated by a copious admixture of sand, so as to approach to sandstone; and in not a few instances it derives considerable hardness from an increase of calcareous matter. Nodules of argillacous limestone, more or less ferrous, are very regularly distributed in rows throughout the mass; they are generally small, and those in some bands nearly globular, resembling small cannon-balls; these latter contain much pyritous matter diffused throughout their mass. Some of the less ferruginous ones have been formed around a specimen of *Ammonites capricornus* as a centre; these are more frequently met with detached and not in rows. In Drayton's fanciful poem the 'Polyolbion' are some very characteristic, though quaint, lines descriptive of the rounded nodules of Huntcliff:—

> "The Rocks by Moultgrave too, my glories forth to set,
> Out of their crained cleeves, can give you perfect Jet;
> And upon Huntcliff Nab you everywhere may find
> (As though nice Nature lov'd to vary in this kind)
> Stones of a Spherick forme of sundry Mickles fram'd,
> That well they Globes of stone, or bullets might be nam'd,
> For any Ordnance fit; which broke with Hammer's blowes,
> Doe headlesse Snakes of stone within their Rounds enclose."

These nodules were subsequently a stumbling-block to early speculators, who cited them as proving the Ammonite to be a *lusus naturæ*, since no animal could penetrate so hard a stone!

We do not perceive in the series of beds thus indicated that uniformity of distinct features that would justify their being united into one zone and separated from that below on purely lithological grounds. Indeed those who limit themselves entirely to arguments derived from the latter would actually draw the line between the Lower and Middle Lias through the very midst of this series. Un-

doubtedly the change in lithological character is nearly as marked here as anywhere in the Lias throughout the Yorkshire area; but when we turn to the palæontology, as we are bound to do, no change is perceptible, but we are forced, if we value this evidence at all, to unite them into one zone, which, though varying, has still some general characteristics even from a lithological point of view—though the passages from the laminated shale of the *Jamesoni*-beds to the marly shales of the *capricornus*-beds, and those from the latter to the sandstone series of the *margaritatus*-horizon, are so gradual that it is impossible to determine the limits of the *capricornus*-beds upon the lithology alone. The range of the characteristic Ammonite, however, accords very well with the differences in mineral condition that we have pointed out.

Thickness.—There are four sections on the Yorkshire coast which exhibit the full thickness of the *capricornus*-beds; and though we have not been enabled in each case to measure bed by bed, yet we offer with some confidence the following thicknesses for each:—

Robin Hood's Bay, North Cheek.—Hard, sandy, and marly shales, interspersed with strong oyster-bands, and forming strong rock-beds, 60 feet; blue sandy shales becoming more argillaceous towards the base, with scattered rows of doggers and nodules containing *A. capricornus* and *A. fimbriatus* near the bottom, 64 feet: total 124 feet.

Rockcliff.—*Ammonites capricornus* occurs in marly sandstone 145 feet below the base of the Upper Lias; and *A. fimbriatus*, which never descends below the base of the *capricornus*-beds, is found at a depth of 290 feet from the top of the Middle Lias; the intervening strata measure therefore 145 feet.

Huntcliff.—Similar measures at this section give 160 feet for this group.

Coatham Scars, Redcar.—The flat expanse of rocks exposed at low water consist of the lower and middle beds of the Middle Lias; these have a dip of 10°; and the *capricornus*-shales and marls have a breadth of not more than 630 feet, corresponding to a thickness of 115 feet.

These several measures indicate a remarkable variation in the thickness of the *capricornus*-beds; but their attenuation in a south-easterly line from Huntcliff is a phenomenon in which the greater portion of the Middle Lias takes part, and one which is also exhibited in a south-westerly direction from the same point. The mineral condition, however, presents very little variation, as the detailed sections hereafter given show.

The *capricornus*-beds occupy positions on the coast which render them well situated for study, and make them attractive. Thus they run out boldly into the sea at the north of Robin Hood's Bay; they form the base of the fine precipice of Huntcliff, as we walk east from Saltburn; and they run out in large flat scars near the picturesque village of Staithes. We proceed to give the details of the sections that may be observed at these localities.

Typical Sections.

Section of capricornus-*beds, North Cheek, Robin Hood's Bay.*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Dark speckled shales	4 8	*Ammonites margaritatus.*
	Strong ironstone dogger	0 8	*Protocardium truncatum.*
	Dark speckled shale	0 5	
	Base of *margaritatus*-beds.		
1.	Series of thin oyster-bands with sandstone between, ripple-marked	4 5	*Gryphæa cymbium*, var. *depressa.*
2.	Hard speckled shales	4 8	
3.	White hardened band (conspicuous at Castle Chamber).	0 6	
4.	Brown speckly shales...............	8 6	Wood.
5.	Sandy laminated rock, oysters at the base, 10–12 in.	0 10	*Gryphæa cymbium*, var. *depressa.*
6.	Brown speckly shales...............	1 4	
7.	Line of ironstone doggers	0 4	*A. capricornus.*
8.	Brown speckly shales	7 4	*A. capricornus.*
9.	Sandy variable bands, occasional patches of oysters.	0 10	
10.	Brown speckly shales with large doggers irregularly scattered.	3 6	*Gryphæa cymbium*, var. *depressa.*
11.	Thin laminated shale...............	1 8	[*pressa.*
12.	Oyster-bed (the lowest)............	0 5	*Gryphæa cymbium*, var. *de-*
13.	Hard whitish slippery shales ... Irregular white doggers.	4 9	*A. capricornus*, *Pholadomya Beyrichii.*
14.	Similar shales........................ Irregular white doggers.	4 6	
15.	Similar shale .... Irregular bands of white doggers.	5 0	
16.	Similar shales........................	11 0	*A. capricornus.*
17.	Small round nodules	0 2	
18.	Darker shales still hard............	2 10	
19.	Strong ironstone dogger	0 8	
20.	Bluish hard sandy shale	15 6	
21.	Ironstone dogger, 6–8 in.	0 6	
22.	Similar shale	8 4	
23.	Ironstone dogger	4–6 in.	*A. capricornus*, *Modiola scalprum.*
24.	Similar shale	5 0	
25.	Thin lenticular dogger	0 3	*Monotis inæquivalvis.*
26.	Similar shale	4 5	*A. capricornus*, *Inoceramus ventricosus*, *Modiola numismalis.*
27.	Ironstone dogger, 5–10 in.	0 5	*A. capricornus.*
28.	Whitish crumbly hard shale......	5 0	
29.	Dogger	0 6	
30.	Shale	11 0	
	Irregular dogger		
	Carried forward	114 6	

Section of capricornus-*beds, North Cheek, Robin Hood's Bay* (continued).

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Brought forward..............	114 6	
31.	Shale	4 0	*A. fimbriatus.*
32.	Brown hard band of shale	0 3	
33.	Shale	5 3	
	Base of *capricornus*-bed.	124 0	
	Variable dogger	2 6	
	Shale with indurated bands and doggers	13 6	*A. striatus.*

The *capricornus*-beds in Robin Hood's Bay only extend for a short distance along the shore, crossing it in an oblique direction. At the north corner, the rocks that run out into the sea are the highest of the *capricornus*-beds. There is a hollow worn in the cliff, called Castle-chamber, the floor of which is nearly the lowest of the *margaritatus*-zone; the next hard band is the highest of the *capricornus*-shales. The beds are here gradually rising; and the lines of nodules cross the scar consecutively. The intervening shales are worn into domes; and the scattered nodules in them contain the characteristic Ammonite. A little further to the south all the series may be seen in the cliff, where the uppermost oyster-bed and many regular rows of doggers are very conspicuous, and below these again lies the *fimbriatus*-bed, while the *Jamesoni*-beds are reached some short distance from the bottom.

Huntcliff (West End). Section of the Junction-beds between the Zones of Ammonites Jamesoni *and* A. capricornus.

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
1.	Greenish sandy beds .... Blue hard shale in blocks and bands of doggers .... Blue hard shale in thick blocks	30 0	*Ammonites hybrida, Leda graphica, Limea acuticosta, Monotis inæquivalvis. Chemnitzia Blainvillei.*
2.	Dogger band .... Blue hard shale in large blocks with bands of greenish shaly sandstone. Radiated crystals of selenite in the partings	10 0	*A. fimbriatus, A. capricornus, Belemnites clavatus, Monotis inæquivalvis, Inoceramus ventricosus, Lima Eucharis, L. Hermanni, Pecten lunularis. P. æquivalvis, Rhynchonella tetrahedra.*

Huntcliff (West End). Section of the Junction-beds between the Zones of Ammonites Jamesoni *and* A. capricornus *(continued).*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
3.	Nobular band of argillaceous limestone.	0 5	
4.	Greyish blue hard shale in thick blocks, somewhat sandy.	6 4	*A. capricornus, Belemnites clavatus, Inoceramus ventricosus.*
5.	Nodular bank of brown argillacous limestone.	0 5	*Pecten lunularis.*
6.	Greyish blue sandy shale	6 3	*P. æquivalvis.*
7.	Double bed of argillaceous limestone in irregular broken masses.	0 10	
8.	Blue shales .... Spherical balls of pyritous and argillaceous limestone .... Blue shale .... Lenticular doggers occasionally. Blue shale	9 0	*A. fimbriatus, A. capricornus, Belemnites clavatus, B. elegans, Inoceramus ventricosus, Pholadomya Beyrichi, Pecten priscus.*
9.	Lenticular argillaceous limestone masses, and globular doggers; cone-in-cone structure atop in places.	0 10	*Belemnites clavatus, Inoceramus ventricosus.*
	Assumed base of the *capricornus*-beds.		
	Blue shale .... Detached doggers at a depth of of 2 ft. 6 in......................... Blue shale	15 0	*Chemnitzia Blainvillei, Actæonina marginata. Belemnites elegans,* wood.
	Large depressed irregular doggers	0 5	*Chemnitzia Blainvillei.*
	Blue shale	5 9	*Pecten æquivalvis, Ditrypa circinata.*
	Argillaceous limestone, in a broken band or as doggers.	0 4	*Pecten priscus.*
	Blue shale	6 0	Wood.
	Large depressed doggers	0 5	
	Blue shale .... Detached doggers at depths of 3 ft. and 2 ft. 4 in...............	4 9	*Belemnites* and wood.
	Large depressed doggers wide apart.	0 5	*Chemnitzia Blainvillei, Actæonina marginata, Gresslya ovata, Gervillia erosa.*
	Blue shale, with occasional doggers at depth of 3 ft. and 2 ft. 4 in.	7 8	*Belemnites elegans, Pecten priscus, P. lunularis, Plicatula spinosa, Ditrypa circinata.*
	Lenticular doggers, wide apart...	0 5	

Huntcliff (West End). Section of the Junction-beds between the Zones of Ammonites Jamesoni *and* A. capricornus *(continued).*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Blue shale	6 0	
	Lenticular dogger	0 4	
	Shale	5 0	*Belemnites.*
	Scattered doggers .... Blue shale	1 0	*A. striatus, Belemnites elegans, Pecten priscus, Pentacrinus.*
	Irregular dogger.....................	0 4	*A. striatus.*
	Blue shale with shell-masses......		*A. Jamesoni, Pinna folium,* &c.

The upper portion of the *capricornus*-beds is here inaccessible; but the lower parts are very conveniently situated for examination, and form the upper region of the scars. The bed No. 7 is very conspicuous, and forms a good line to measure from; it is at a man's height at the northern corner of the cliff, where washed by the tide. From the shale immediately below it, or, rather, from a soft intervening brash, have been obtained all the Foraminifera and Entomostraca quoted from the locality. We have given a view of the fine cliff here in the frontispiece, which is taken from a photograph. As we pass along the coast towards Skinningrove we find the upper beds coming down one by one; and each runs out obliquely towards the sea, giving rise to scar after scar, which may be examined for fossils. There is some little difficulty, however, in tracing them into the cliff until we come to Hummersea; so that instead of combining the two sections, we prefer to give that at the latter place by itself.

Hummersea, near Skinningrove. Section of the upper part of the capricornus-*beds.*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Blue flaggy calciferous sandstone, very fossiliferous.	1 5	*Ammonites margaritatus, Dentalium giganteum,* &c.
	Blue calciferous sandstone.	0 5	
	Base of the *margaritatus*-beds.		
1.	Marly sandstone, gypsum in the joints.	4 3	*A. capricornus, Pecten æquivalvis, Gryphæa cymbium, Protocardium truncatum, Rhynchonella calcicosta, Ditrypa circinata.*
	Carried forward	4 3	

Hummersea, near Skinningrove. Section of the upper part of the capricornus-*beds* (*continued*).

No.	Lithology.	Thickness. ft.	in.	Fossils.
	Brought forward..............	4	3	
2.	Sandstone, gypsum in the joints	1	7	
3.	Calciferous sandstone, ditto	0	3	
4.	Sandy marls, ditto	2	4	*Pecten æquivalvis.*
5.	Bluish-brown, fine-grained argillaceous limestone, in the form of lenticular nodules.	0	4	
6.	Marly sandstone.....................	5	9	
7.	Soft sandstone with oysters at the base.	1	3	
8.	Mottled sandy marls	11	0	
9.	Denser ditto	2	0	
10.	Mottled sandy marls	4	0	
11.	Brown compact argillaceous limestone doggers.	0	4½	
12.	Mottled sandy marls	4	8	*Pleuromyæ.*
13.	Blue flaggy sandstone	1	0	
14.	Sandy-bed	0	6	
15.	Oyster-band	0	4	
16.	Hard sandy band	1	5	
17.	Oyster-bed, usually a hard ferro-argillaceous matrix, sometimes a reddish-yellow sandstone.	0	3	*A. capricornus, Pecten æquivalvis, P. substriatus, Protocardium truncatum, Monotis inæquivalvis* (c), *Leda minor, Gryphæa cymbium, Rhynchonella calcicosta, Ditrypa 5-sulcata, Ophioderma Milleri.*
18.	Sandy shale..........................	0	6	
19.	Oyster-band	0	6	*Belemnites elegans, Gryphæa cymbium, Pecten æquivalvis, P. substriatus, Monotis inæquivalvis, Rhynchonella calcicosta.*
20.	Sandy shale..........................	2	0	*A. capricornus, Bel. breviformis, Gryphæa cymbium, Pholadomya ambigua, Modiola scalprum.*
21.	Dark blue to brown ferro-argillaceous limestone, weathering red.	0	4	*Greslya ovata.*
22.	Bluish-grey sandy marl	0	7	
23.	Shell-bed.............................	0	1	*Pholadomya ambigua.*
24.	Bluish-grey sandy marl, detached doggers.	3	0	*Belemnites elongatus, Gryphæa cymbium.*
25.	Marly shale with occcasional calciferous sandstone masses. Sandstone parting. Grey marly shale.	2	3	*Pecten æquivalvis, P. substriatus. Greslya ovata, Rhynchonella calcicosta.*
	Carried forward	50	6½	

Hummersea, near Skinningrove. Section of the upper part of the capricornus-*beds (continued).*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Brought forward...............	50 6¼	
26.	Grey marly shale with three rows of blue hard argillaceous limestone doggers.	5 8	*A. capricornus, Belemnites clavatus, B. elegans, Actæonina marginata, Chemnitzia Blainvillei, Protocardium truncatum, Pecten æquivalvis, Lima Hermanni, Limea acuticosta, Monotis inæquivalvis, Gervillia erosa, Hippopodium ponderosum, Rhynchonella calcicosta.*
27.	Bluish shale with roundish nodules. Base of cliff, high-water mark.	3 0	*A. capricornus, Pecten æquivalvis, Rhynchonella.*
	Total thickness	59 2¼	

In the scars corresponding to these various beds *Ammonites fimbriatus* occurs both towards the top and towards the bottom; but the corresponding bed in the section being doubtful, we omit it from the lists thence obtained. Although we cannot with absolute certainty correlate these beds with those at Huntcliff, yet by tracing as well as may be each bed along the cliff, and estimating the thickness, we can assure ourselves that no part of the one corresponds to any part of the other, but rather that there is an intervening series of about 45 feet. In the following section further east, at Colburn Nab, where a good succession may be traced in the cliff-face, we find no detailed, though a general, similarity with the above series; the whole, however, is more arenaceous, and is characterized by the abundance of the remains of star-fishes.

Colburn Nab, Staithes. Section of the upper part of the capricornus-*beds.*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Marly sandstone	1 0	
	Greyish sandstone with black stains.	1 4	
	Marly sandstone....................	3 3	
	Greenish-grey sandstone	4 7	
	Green sandstone with reddish-coloured patches.	3 9	
	Hard sandstone.....................	1 6	

Colburn Nab, Staithes. Section of the Upper Part of the capricornus-*beds* (continued).

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Greenish-grey sandstone	1 7	
	Grey calciferous sandstone	1 0	
	Grey softish sandstone	0 11	
	False-bedded flaggy calciferous sandstone in two blocks.	2 0	
	Blue hard calciferous sandstone weathering grey.	0 6	*Pecten lunularis, Protocardium truncatum, Rhynchonella calcicosta.*
	Assumed base of the *margaritatus*-beds.		
1.	Compact sandy marl, layer of oyster at the top.	2 0	
2.	Compact sandy marl...............	8 2	
3.	Grey friable sandy marls	5 5	
4.	Grey soft sandstone in block, oyster on under surface.	3 9	Starfish-beds.
5.	Sandy shale..........................	2 3	Starfish-beds.
	Indurated sandstone	0 0½	Starfish-beds.
6.	Grey marl	2 9	Starfish-beds.
7.	Hard sandstone, slightly calcareous.	0 4	
8.	Bluish marl	5 2	*Limea acuticosta.*
9.	Grey argillaceous sandstone, striped with thin bands of whitish sandstone in the lower part.	3 9	Scattered oysters (*G. cymbium*), wood. Base of cliff washed at high tides.
	Layer of oysters	3 4	
10.	Grey sandy marls with detached nodules	3 4	*Ammonites capricornus, Protocardium truncatum, Pecten æquivalvis, P. lunularis, Avicula inæquivalvis.*
	Dogger band of argillaceous limestone.	to 4	
11.	Grey marly shale with thin bands of oyster.	5 8	*Pecten æquivalvis.*
12.	Oyster-band	0 4	
13.	Grey marly shales, layer of oysters and scattered doggers.	4 2	
14.	Oyster-band in ferro-argillaceous matrix, weathering red.	0 8	*A. capricornus, Eucyclus undulatus, Leda minor, Gervillia erosa, Pecten substriatus, Avicula inæquivalvis, Limea acuticosta, Rhynchonella calcicosta.*
15.	Grey shale	0 9	
16.	Dogger-band	0 4	
17.	Grey marly shale with oysters...	6 4	
18.	Impure calcareous rock...........	0 5	
	Grey shales and doggers.		

The underlying shales with rows of doggers may successively be examined as they rise into the sea-cliffs, proceeding in a general north-westerly direction along the shore. At Red Nab an oolitic ironstone 8 or 9 inches in thickness is situated at a depth of about 50 feet in the *capricornus*-beds. On the shore opposite the summer-house on the edge of the cliff at Boulby village is a row of nodules, containing *Ammonites fimbriatus*, seaward of which are the *Jamesoni*-shales. There is also a band about 14 feet above this, containing *A. fimbriatus*. In the Boulby cliffs, the *capricornus*-beds attain their greatest elevation, the base being about 40 feet above high-water mark.

From Rockcliff to Hummersea the line of section is oblique to the south-easterly dip of the beds; so that there is a steady decline of the strata in this direction, and at the latter place the top beds only of the series are visible. For a similar reason they rise toward Huntcliff, where they occupy the larger portion of the cliff-face, but do not attain to so great an elevation as at Rockcliff—and again decline towards Saltburn, before reaching which place they are covered up by Boulder-clay. At Huntcliff there is another bed containing *A. fimbriatus*, which is at the base of the first corner; and this is the base of the series.

The section of the Coatham Scars is very rarely in a condition favourable for examination, and when at its best offers little inducement for close study. The succession of the beds is indicated in the general section of these rocks, p. 84.

Other Sections and Exposures along the Liassic Escarpment.

Capricornus-shales are seen on the banks of Rousby Beck, near to its junction with Easington Beck; thence along the course of the united streams, now called Staithes Beck, to the sea are numerous exposures of the upper part of this series.

From Huntcliff the *capricornus*-beds trend inland with the sweep of the hill country, occupying a belt towards the base of the slopes, which is very generally covered with pasturage and more or less encumbered with Boulder-clay and talus from the higher grounds. The exposures present little of interest beyond the slight aid they afford in drawing the boundary between the Middle and Lower Lias.

Black micaceous shales at an elevation of 300–275 feet in Yearley Wood may belong here; and the oyster-bands in the upper part of the series are cut through by the incline of the railway from Kirkleatham Mines. The so-called "Sandstone Quarry," in Scarth Bank, Wilton, exhibits a thickness of about 25 feet of micaceous, sandy, and marly shales with two rows of ironstone nodules: no fossils were observed; but the beds may belong to the lower part of this horizon.

The railway-cutting to the east of Belman-Bank Farm, Guisborough, exhibits a considerable section, comprising compact shale, with layers of *Gryphæa cymbium*, 14 inches, underlain by pepper-and-salt-coloured shaly marls, strongly jointed into rhomboidal masses, which contain *Ammonites capricornus*. Similar beds are

exposed on the incline ascending to the Belman-Bank Ironstone Mines.

Black shales are exposed along the sides of the bridle-road which leads up to High Cliff from Hutton Hall. Sandy shales with doggers are seen forming the north slope of the tabulated hill between Hutton and Pinchinthorpe. Shales with concretionary balls occur on the north-west front of Roseberry. These exposures are probably of the *capricornus*- or *Jamesoni*-series.

The mural faces of the Langbarugh basaltic quarry are constituted of indurated sandy shales, which may belong to this horizon. The fossils observed are *Pecten æquivalvis*, *P. lunularis*, *Limea acuticosta*, and *Gresslya*, sp.

The banks of the river Leven, between Easby and Kildale, afford very good sections of the Middle Lias from the horizon of *Ammonites Jamesoni*, to the hard bands of the *margaritatus*-series. In the bank of the Old Mill, below Bleach-Mill Farm, there are displayed hard shales with spherical nodules of ferruginous limestone, and a band 5 inches thick of an oolitic ironstone, having the same characters as, but thinner than, the ironstone-band in the *capricornus*-beds at Red Nab, Staithes, and Huntcliff. We have collected here *Ammonites capricornus*, *Modiola numismalis*, and *Belemnites elegans*.

What appear to be *capricornus*-shales are exposed in the road leading from Borrowby into Basedale. But along the bold escarpment by Cringley and Carlton Moors, full sections of the upper part of the Middle Lias occur, especially at Halliday Slack and Little Bonny Cliff. In no case have we obtained palæontological evidence of the age of the shales containing ironstone-balls and doggers, which occupy so conspicuous a place in these sections; but their subordinate position to the fossiliferous flagstones of *margaritatus*-beds, and their lithological character, justify us in assigning them to the *capricornus*-series. For the same reasons we refer to it the thin argillaceous sandstones and sandy marls with *Modiola scalprum*, cut through by the railroad between Swainby and Potto, and the greyish sandy shales of Potto Hill. In Swainby Beck, above Swainby Mill, a limited section is exhibited of similar strata; it is as follows:—

Ironstone dogger, sandy shales 4 inches; shales with sandy lumps, 12 feet, containing *Myoconcha decorata* and *Modiola scalprum*; shaly sandstone 3 inches, with *Gresslyæ* and *Belemnites*; and sandy shales with *Modiola scalprum*.

The Cod beck at Osmotherley affords sections of marly shales with rows of nodular limestone referable to this group of strata, but too detached to throw much light upon the general characteristics of the Middle Lias in this area.

In the side of the stream, by a wood near Crake Bank, Thornborough, are some hard sandy shales dipping west. No fossils are seen in them; and it cannot be determined to what zone they belong, except that lithologically they are undoubtedly Middle Lias, and from their position and character most probably belong to this portion of it. This is a solitary exposure over miles of warp-covered country.

Flags of the oyster-bands are found in the neighbourhood of Easingwold.

Exposures within the Liassic Inliers.

Westerdale.—The bottom lands in this dale are chiefly based on the *margaritatus*-beds; but the deep cutting made by the Esk near the village of Westerdale reveals marly shales with doggers, upon which repose the flaggy sandstones of the *margaritatus*-beds; these may be regarded as belonging to the horizon now under review.

Danbydale.—Stratigraphically the deepest part of this valley is that of the stream-course, commencing by the church, and thence southward for a mile, which doubtless is occupied by the *capricornus*-beds; in fact, a section of them is well displayed in a deep stream-cutting entering from the east about half a mile above the church, where a considerable thickness of shales is seen dipping N.W. and overlain by the sandstone of the *margaritatus*-series.

The Valley of the Esk, commencing at about a mile below Grosmont, is excavated for about two miles in the *capricornus*-shales.

Bilsdale.—We have already indicated the existence of the *Jamesoni*-beds in this dale, above the cliff exposing them near Chopgate. There is a broken road leading up to the jet-holes from Esk House. In this road the whole Middle Lias series above the *Jamesoni*-beds is passed over; and though the section is too irregular for accurate measurements, many of the different beds are exposed, and their fossils may be collected. The whole thickness seen is 300 feet; of these 25 feet may belong to *spinatus*-beds, 120 feet (?), or less, to the *margaritatus*-beds, and 255 feet to the *capricornus*-shales &c., containing *Pecten substriatus*, *Limea acuticosta*, *Pholadomya ambigua*, *Chemnitzia Blainvillei*, *Rhynchonella tetrahedra* (?), and consisting of sandy shale with occasional patches of *Gryphœa cymbium*, var. *depressa*. Further to the south, near a house called Crookleth, is a cliff which, from its depth, agrees in position with this zone, and contains *Pecten substriatus*, *Belemnites clavatus*, *Limea acuticosta*, and *Leda galathea*. *Capricornus*-beds, therefore, occupy a considerable portion of the lowlands of the dale towards its central part, though its exposures are not numerous.

Raisdale.—Sandy shales and soft shales with doggers, belonging either to the *capricornus*- or the *Jamesoni*-beds, or both, are exposed in the lower part of the stream-course which joins Raisdale Beck on the west, at Low Crosslets; and there is a pretty considerable section of marls beneath the *margaritatus*-sandstones in Great Gill, another affluent of Raisdale Beck.

Bransdale.—The level of the *capricornus*-series is possibly reached in the central and depressed part of this dale; but the area, if any, must be very small.

Farndale.—The lowest beds cropping to the surface in this vale are those of the *capricornus*-zone, which are exposed in the banks of the river Dove at Low Mill, their most southerly extension, and northward to beyond Church House, up West Farndale, in which, at

Mason House, is a good section, showing about 20 feet of hard sandstone with oyster-bands, 30 feet of softer shales, and 20 feet or more of harder shale with doggers.

PALÆONTOLOGY.

The total number of species recorded for this zone is 64, the bulk of which belong, some to the overlying and others to the underlying zone. The chief characteristics of the fauna are its peculiar Ammonites and the great variety of the starfish and brittlestars. The restricted species embrace most of the above; and to these must be added *Pleurotomaria foveolata* and *Pholadomya Beyricki*. *Eucyclus undulatus*, *Anomia numismalis*, *Inoceramus ventricosus*, and *Gervillia erosa* are rarely met with beyond the confines of the zone, within which they are tolerably abundant.

The chief repositories of the mollusks are the limestone-bands with oysters, and of the echinoderms the overlying sandy beds, near to the top of the series. We have also collected largely from the mass of the shales and from the hard doggers (which occasionally yield fossils) throughout the rest of the zone.

It will be observed, from the names of the localities in Part II., that very few fossils of this series have been collected inland, and at only a few places.

The crumbling of the marl or shale from the face of an inland cliff or bank destroys to a considerable extent the impressions of fossils, to which circumstance we might attribute their absence at these places; but the hard fossiliferous bands appear to be absent in the attenuated sections of this zone, and we incline to the opinion that concurrent therewith there is a paucity of life.

List of Fossils from the Zone of A. capricornus.

Ichthyosaurus, sp.
Plesiosaurus, sp.
Ammonites capricornus.
—— defossus.
—— fimbriatus.
—— subarmatus.
—— Henleyi.
—— Bechei.
Belemnites clavatus.
—— apicicurvatus.
—— elegans.
Chemnitzia Blainvillei.
—— citharella.
Eucyclus undulatus.
Pleurotomaria foveolata.
Actæonina marginata.
—— ilminstrensis.
Gryphea cymbium, var. depressa.
Anomia numismalis.
Pecten calvus.
—— lunularis.
—— substriatus.
—— æquivalvis.
Lima Hermanni.
Limea acuticosta.
Plicatula spinosa.
Monotis inæquivalvis.
—— calva.
Gervillia erosa.
Inoceramus ventricosus.
—— substriatus.
Modiola scalprum.
—— numismalis.
—— Thiollieri.
Macrodon intermedius.
Cucullæa Münsteri.
Leda galathea.
—— minor.
—— graphica.
Protocardium truncatum.
Astarte striato-sulcata.
Hippopodium ponderosum.
Myoconcha decorata.
Pholadomya ambigua.
—— Beyrichi.
Pleuromya ovata.
—— costata.
Thracia Grotiana.

Rhynchonella plicatissima.
—— calcicosta.
—— variabilis.
—— subserrata.
Bairdia liassica.
Cythere crepidula.
Ditrypa quinquesulcata.
—— circinata.
Cidaris Edwardsii.
Uraster carinatus.
Tropidaster pectinatus.

Luidia Murchisoni.
Plumaster ophiuroides.
Astropecten Hastingiæ.
Ophioderma Milleri.
—— Gaveyi.
—— carinata.
Ophiolepis Murrayi.
—— columba.
Pentacrinus Milleri.
—— interbrachiatus.

CHAPTER XII.

ZONE OF AMMONITES MARGARITATUS.

The sections we have described as typical of the *capricornus*-beds are equally serviceable to exemplify the lithological and palæontological characteristics of the zone of *Ammonites margaritatus*. In general the strata consist of two groups:—the lower, sandstones more or less calcareous; and the upper, shales with doggers and ironstone-bands. Like the underlying series the *margaritatus*-beds diminish in thickness in all directions from the area of their greatest development, in the cliffs between Staithes and Saltburn.

The lower portion of the *margaritatus*-beds has been described by Young and Bird, under the name of the "Staiths beds," from the circumstance that these strata rise up at the village of that name, where, too, they may be most conveniently studied. This portion consists chiefly of various beds of sandstone, some of which are thick and massive, usually false-bedded, and often ripple-marked, others more argillaceous, whilst some are calciferous, and even acquire the nature of an arenaceous limestone. The more calcareous beds are usually crowded with the shells; and layers of *Protocardia* and oysters between some of the sandstones are traceable over wide areas. The thickness of these rocks is as much as 50 feet at Huntcliff, and at Hawsker 47 feet.

The upper portion consists of shales, somewhat sandy and micaceous below, with ironstone seams and clay-ironstone nodules imbedded in them. These lithological characteristics are continued into the overlying palæontological group of *Ammonites-spinatus* beds, which in certain localities are so connected with the *margaritatus*-zone that, in the absence of the characteristic organic remains, separation is impossible. They will be described more in detail under the head of the ironstone-beds. The band of ironstone known as the "Bottom seam" or "*Avicula*-seam" is taken as the top bed of the series, its dominant fossils being those of other parts of the *margaritatus*-series. The thickness is variable: at Hummersea these rocks measure 62 feet in thickness, at Staithes 66 feet, and at Hawsker 44.

From the description of this and the two preceding zones it will appear that we may briefly divide the Middle Lias, as regards lithological features, into an upper argillaceous series with ironstone-bands, an arenaceous series with some limestones, and a lower argillaceous series with clay-ironstone bands. Phillips and others who

have followed this classification have, as before stated, included the lower argillaceous series (our *armatus*-, *Jamesoni*-, and *capricornus* (pars)- zones) in the Lower Lias; to the middle portion (our *capricornus* (pars)- and *margaritatus*-zones) they have given the name "Marlstone series," and to the upper (our *margaritatus* (pars)- and *spinatus*-zones) the name "Ironstone series." From their economic importance it will be of advantage to study these latter together; but to the term "Marlstone series" there are strong objections, which have led us to discard its use, and which we proceed to state.

Inadmissibility of the term Marlstone.—Mr. William Smith subdivided the Lias into Lower Lias, Marlstone, and Upper Lias; and subsequent writers have adopted these terms with much of their original significance and application. It was in fact a recognition that the middle portion of the Lias contained hard stone bands; and thus the term Marlstone included all such. In cases where representatives of the uppermost portion only occurred, as in Warwickshire, Oxfordshire, and Northamptonshire, the term would naturally be restricted to them; nevertheless Phillips, who, from his connexion with Smith, must be regarded as at that time his interpreter, distinctly correlates, in his 'Geology of Yorkshire,' the "ironstone and sandstone strata with *Terebratulæ*, *Pectines*, *Cardia*, *Aviculæ*, &c." with the "marlstone of Northamptonshire." To these in Yorkshire he assigns a thickness (obviously underestimated) of 150 feet. In Gloucestershire a similar series occurs—namely, an upper rock-bed from 10 to 20 feet thick, and a lower series of sands and clays with their bands of calcareous sandstones and ferruginous nodules, altogether attaining a thickness of about 150 feet, which are all included under the term Marlstone by the Geological Survey (Mem. Geol. Surv. sheet 44, p. 18). Again, the so-called marlstone of Radstock belongs to the *Jamesoni*-series. One interpretation, therefore, of the term is "all the hard beds of the Middle Lias." The most constant member, however, of this series is the rock-bed at the top, which may be traced step by step from Cleveland (where it forms the main seam of ironstone), through Oxfordshire, to the vicinity of Bath in Gloucestershire. In some parts this is almost the only hard band, *e. g.* at Banbury, where the series is ferruginous marlstone 12 feet, shales and thin limestone 18 feet (Beesley's 'Geol. of Banbury,' p. 5). From this circumstance and from the fact that Smith's original terms were taken from these more attenuated sections, the term marlstone has come to receive a second interpretation, "the hard rock-bed, often an ironstone, at the top of the Middle Lias."

Again, in Yorkshire, where these hard beds are most fully developed and it becomes obvious that two divisions must be made, the term marlstone has unfortunately become attached to the *lower* of them. Thus Prof. Phillips, changing his former nomenclature, speaks of an ironstone *and* marlstone series (Quart. Journ. Geol. Soc. vol. xiv. p. 96, 1858); and so, more recently, he writes, the "marlstone is not worked for iron in Yorkshire, but it appears to be only from its reduced equivalent in Oxfordshire that the ore has been obtained;" from which it is obvious that he *excludes* the Cleveland

main seam from the term. In this he had been preceded by Hunton in 1836, who spoke of the ironstone *and* marlstone series, and followed by Bewick in 1861. This has probably arisen from the natural objection of geologists to call an ironstone a marlstone, when neither it nor any Yorkshire bed can be appropriately called by that name. Thus we have a third meaning for marlstone, viz. "the sandstones and calcareous rocks below the ironstone."

A term which has thus three meanings, and is moreover totally inappropriate as descriptive, is self-condemned. We substitute therefore that of Middle Lias, and particularize the various portions of it by their lithological and palæontological characteristics.

We now proceed to give some of the typical sections of the *margaritatus*-beds.

Typical Sections.

Hummersea.

No.	Lithology.	Thickness. ft.	in.	Fossils.
	Ammonites-spinatus beds.			
	Upper *margaritatus*-beds.			
1.	Bottom seam of ironstone ...	1	4	
2.	Black laminated shale	8	4	
3.	Clay-ironstone, slightly oolitic	0	4	
4.	Black shale........................	10	2	
5.	Blue argillaceous limestone ...	0	1½	
6.	Black laminated shale	4	0	
7.	Clay-ironstone	0	2	
8.	Shale	0	8	
9.	Nodular band of blue ferro-argillaceous limestone, speckled with white grains.	0	9	
10.	Shale	0	10	
11.	Oval doggers of argillaceous limestone.	0	4	
12.	Tough micaceous shales	4	10	
13.	Small doggers of argillaceous limestone .... Tough micaceous shales	17	0	*Pecten lunularis, Limea acuticosta, Gervillia erosa, Leda subovalis.*
14.	Indurated sandy shale	1	0	
15.	Blue hard sandy shale	8	7	*Leda graphica, Pecten lunularis.*
16.	Grey oval septariate nodules	0	4	
17.	Hard sandy shales...............	3	9	
18.	Calcifero-argillaceous balls ...	0	3	
	Lower *margaritatus*-beds.			
19.	Blue shaly sandstone	2	6	*Protocardium truncatum.*
20.	Blue shaly calciferous sandstone.	0	7	
21.	Hard sandy shales...............	1	4	
	Carried forward	67	2	

Here we reach the base of the cliff; but on the south side of the harbour the following beds are exposed at low tide:—sandy shales; impure limestone-bands; grey marly sandstone; blue micaceous sandstone: about 10 feet in thickness, containing *Protocardium truncatum*, *Pecten æquivalvis*, *Belemnites virgatus*.

The fossils are chiefly obtained from the doggers in bed no. 16.

The shells often constitute the mass of the dogger, having a mere crust of argillaceous limestone. Generally in each mass one species largely predominates; so that it is probable that, on a visit, specimens of the smaller species may be obtained in sufficient abundance to stock all the museums in the kingdom, whilst on subsequent occasions few or none of the particular kinds may be collected. If the matrix of the shell-masses has undergone slight decomposition the fossils are extracted with ease and in a perfect state of preservation, occasionally extending to that of colour.

The species gathered from these nodules are *Ammonites margaritatus*, *A. capricornus* (very small), *Discohelix aratus*, *Dentalium elongatum*, *Chemnitzia Blainvillei*, *C. citharella*, *Eucyclus undulatus*, *Arcomya arcacea*, *Monotis inæquivalvis*, *Protocardium truncatum*, *Cardita multicosta*, *Cardinia lævis*, *C. antiqua*, *Cypricardia cucullata*, *Ceromya petricosa*, *Goniomya hybrida*, *Hippopodium ponderosum*, *Leda minor*, *L. galathea*, *L. graphica*, *Limea acuticosta*, *Pecten æquivalvis*, *P. lunularis*, *Macrodon intermedius*, *Thracia Grotiana*, *Terebratula punctata*.

Cardita multicosta, *Leda minor*, and some other bivalves are found occasionally bored as if by a gasteropod; but curiously enough, no species has been found in this bed or in the associated strata to which such a habit can be inferred from its zoological affinities.

The ravine of the Skelton beck, between Skelton and Marske Mills, presents a section of the upper *margaritatus*-beds, similar to that of Staithes; and in it there occurs a line of fossiliferous doggers, yielding the majority of the species found at Staithes, and occupying the same relative position. The section is given on p. 134.

Hawsker.—In this southern area, though the lower part of the *margaritatus*-beds, which is so well developed and fossiliferous at Staithes, is fairly represented, the ironstone of the upper portion is not equally distinct, and it is not so easy to fix where the *spinatus*-beds above ought to be considered to end, and the *margaritatus*-beds to begin. On the shore of Normanby, on the north-west side, we find the fossils characteristic of *spinatus*-beds, and on the south-east side those of the *margaritatus*-series; but in the wide bay which intervenes only fossils common to the two zones have been met with; the upper limit, therefore, can only be conjectured. These beds cannot be measured on the scar; but they may be in the neighbouring cliff. Nevertheless, the dogger-bands not keeping a uniform level, they do not very well correspond, and it is difficult to correlate them, except in some marked cases. The following measurements are from the cliff:—

No.	Lithology.	Thickness.	Fossils, &c.
		ft. in.	
1.	Strong brown iron dogger ...	0 6	*Monotis cygnipes.*
2.	Friable shales	0 8	
3.	Brown ironstone rough dogger	0 4	
4.	Crumbly laminated shales ...	1 7	
5.	Double knobbly dogger.........	0 4	*Gresslya intermedia, Pleuromya costata.*
6.	Very finely laminated shale ...	1 5	
7.	Dogger-sandstone band.........	0 5	
8.	Dark crumbly shale with occasional doggers.	13 8	
9.	Yellow sandy band	0 5	
10.	Black shale	0 8	
11.	Strong consecutive dogger ...	0 8	
12.	Blue-black softish shale with large fossiliferous doggers scattered.	15 0	*Modiola scalprum, Cardita multicosta, Plicatula spinosa, Pecten æquivalvis, Ammonites margaritatus, Pleuromya costata, Ceromya petricosa, Protocardium truncatum.*
13.	Double consecutive dogger with softer parting.	0 7	*Pecten æquivalvis.*
14.	Soft shale	6 4	Wood.
15.	Fossiliferous dogger, variable, blue shale.	0 10	*Gresslya intermedia, Astarte striato-sulcata, Pecten æquivalvis, Chemnitzia citharella, Leda minor, Belemnites clavatus.*
16.	Strong consecutive rough ironstone.	0 6	*Protocardium truncatum.*
17.	Dark shales with oysters and comminuted fossils.	1 8	*Gryphæa cymbium.*
18.	Doggers...........................	0 3	*Protocardium truncatum.*
19.	Dark blue speckly shales	2 3	
20.	Hard calcareous sandstone with cone-in-cone structure atop (0–12 in.).	......	*Am. margaritatus.*
21.	Dark speckly shales	2 0	*Am. margaritatus, Protocardium truncatum, Monotis inæquivalvis, Pecten lunularis.*
22.	Hard irregular dogger	0 6	
23.	Light speckly shales	3 8	*Dentalium giganteum, Protocardium truncatum, Pecten lunularis.*
24.	White dogger	0 4	
25.	Dark blue speckly shales with irregular doggers.	9 10	
26.	Thin-bedded, rippled and laminated yellow sandstone.	1 3	
27.	Bluish shales	3 6	Wood, calcite.
28.	Dogger-band	0 8	*Protocardium truncatum* (numerous).
29.	Hard speckly shale with hard bands, graduating into	4 0	*Protocardium truncatum.*
30.	Hard yellow sandstone-rock with layers of oysters.	5 0	*Gryphæa cymbium, Protocardium truncatum.*
	Carried forward...........	78 10	

No.	Lithology.	Thickness.	Fossils, &c.
		ft. in.	
	Brought forward	78 10	
31.	Hard dark speckly shales with laminated band.	5 8	*Am. margaritatus*, *Belemnites elegans.*
32.	Laminated sandy beds	0 7	
33.	Dark speckled shales............	4 8	
34.	Strong ironstone dogger	0 8	*Protocardium truncatum.*
35.	Dark speckled shales	0 5	
	Series of oyster and sandstone bands of the *capricornus*-zone.		
	Total	90 10	

With the exception of *Dentalium giganteum*, which occurs in hundreds in one particular bed, and *Protocardium truncatum*, which also monopolizes several, the chief depositories of the fossils of the zone are large lumps of an oval-flattened shape, which are completely made up of them, being no doubt cemented by the calcareous matter of the shells. These lumps are met with chiefly in bed no. 12, which is spread out into a large flat. running outwards at the northern extremity of Normanby Stye Batts; and the doggers of no. 15 are also sometimes of a similar character.

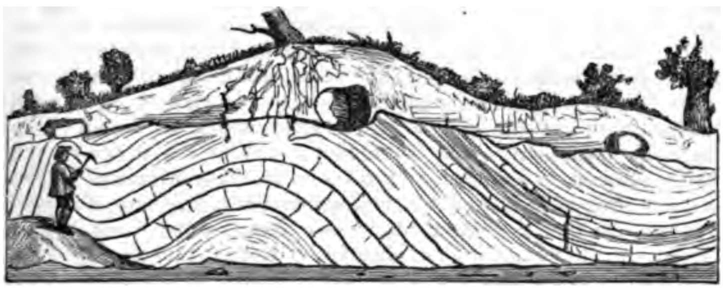
Range and Exposures of the *margaritatus*-beds.

The most southerly exposure on the east coast of strata on this horizon is on the Scars at Old Peak, Robin Hood's Bay, and on the east side of the Peak fault, which upthrows these beds on the west side, to form the top of the low cliff; thence they retire a short distance from the sea-cliffs, following the sweep of Robin Hood's Bay, and by the northerly dip which they acquire are again brought into view on the coast at the north cheek of the Bay, descending the cliff to the northward, and are soon lost under the sea below Hawsker Bottom.

Following the coast northward, they do not emerge from below the sea-level till we round the Old Nab south of Staithes; thence the lower *margaritatus*-beds make conspicuous features in the sea-cliffs as far as Huntcliff. The extensive Boulder-clay plateau between Staithes and Boulby reposes for the greater part upon the *margaritatus*-beds, as determined by the coast-section from Colburn Nab to Boulby, and inland by several exposures along the course of Staithes Beck, as at Dalehouse Mill, Oneholm, and in Low-House Wood. The course of these strata on the coast is interrupted between the west end of Boulby Cliffs and Hummersea by the head of an old valley opening to the north, now filled to above the level of the ironstone with Boulder-clay, and again by a similar but broader depression at Skinningrove. At Huntcliff the series retires from the coast, if we except the outlier on Coatham Scars, the Off Height

and Salt Scar of which are constituted of the sandstone and calciferous rock-beds of this group. The first inland section we encounter is that in the wooded dell through which flows the Saltburn beck to Old Saltburn; it consists of the flaggy sandstones of the Lower *margaritatus*-zones, which are here contorted as represented in the annexed woodcut. It affords a slightly lower horizon than the deepest parts of the section of the Skelton beck, which commences at the top of the sandstones, and will be found described on p. 134.

Fig. 3.—*Contorted Sandstones, Saltburn.*



In Cattersby Glen, east of Huntcliff, the marls are ground and moulded into becks. Exposures on the front of the Upleatham and Eston Hills are very few and obscure. The flat-topped escarpment, running east and west of Yearby and Wilton, consists of a crown of the lower *margaritatus*-beds, the softer *capricornus*- and *Jamesoni*-beds occupying the slope.

An exploring-shaft for ironstone was commenced in these beds, at a place bearing the appropriate name of Wilton Folly. Other exposures of the sandstones are at Normanby and West Hambleton. The upper shale-beds are seen underlying the ironstone, which is in contact with jet-rock near Scugdale Farm, on the south side of the Eston outlier; and the hard beds form an escarpment on the north side of the outlier of ironstone at Tocketts Lythe. On the Guisborough Hills *margaritatus*-beds are exposed in a steep bank at the Waterfall Bridge, on the road from Slapewath to Guisborough; thence the horizon of the hard beds may be traced by the slight terrace they form to Belman Bank; from this point they gradually become an important feature in the landscape. At Hutton and Pinchinthorpe they form tabulated hills, gradually merging into the general mass at Roseberry, on the north and west of which, however, the stone-bands form a bold escarpment, well seen in the part called Cockle Scar, and from which Young & Bird and Phillips obtained some of their Middle-Lias fossils. To the south of Roseberry the *margaritatus*-beds are spread out; but they contribute to the imposing scenery of Cliff Ridge. On the flanks of Easby Moor they again give rise to a bold escarpment, along the base of which the river Leven flows from a little east of Kildale station for a considerable distance in its general easterly course. *Margaritatus*-beds are exposed at

several points between Kildale and Cringley Moor, in the front of which is situated the section already referred to in p. 99. Here, for some distance, the hard beds form crags along the front of the highly inclined slopes of these imposing inland cliffs. The same beds form the base of the picturesque outlier of Whorlton Hill, and are well exposed, as are in part also the upper shales, on the north face of the plateau on which the village of Whorlton is situated.

The Middle Lias flaggy sandstones may be studied in Scugdale, at the back of Holiday House. They are obscurely exposed in the woody slope of Coal-Mire Bank, their presence being indicated by the outburst of springs. Similar indications are observable in Arncliffe Wood; but as they approach Mount Grace they gradually recede from the general slope of the hills; and thence to Clack Farm, near Osmotherley, they constitute a very picturesque escarpment clothed with timber. This feature is lost beneath the Boulder-clay between Osmotherley and Thimbleby; but to the south of the latter place it is resumed, and is traceable, at a distance, by the narrow strip of woodland which stretches away, following the contour of the Oolitic escarpment, by Sow Wood, Hogg Wood, Spring Wood, &c., to within a short distance of Nether Silton: exposures are frequent along this line.

The next exposure is that at Crake Bank, before mentioned (p. 99). At Feliskirk the *margaritatus*-shales occupy the hill-side south of Thirsk road, as noticed also by Marley (*l. c.*); and the boring of this locality, of which a section is given on page 124, left off in these shales, having traversed a band of "marlstone" (?) 1 ft. 9 in. thick. From hence to the south all Middle Lias beds are hidden till we reach the parallel of Sessay, after having passed an east and west dislocation; then, again, we come to a good section of the sandy portion of this zone, on the road-sides leading down from Thormanby towards Easingwold. These beds form a low elongated hill which gradually slopes off in either direction, but which indicates their line of strike; and the same appearance may be met with again to the west, marking clearly their range and leading to the place of their exposure in a cutting near Sessay Station. At Thormanby the beds dip to the south, and have yielded *Protocardium truncatum*, *Monotis cygnipes*, *Macrodon Buckmanni*, *Pecten equivalvis*, *Dentalium giganteum*, *Rhynchonella calcicosta*, *Leda* (sp.), *Acronnia* (sp.), *Gresslya* (sp.).

In the neighbourhood of Easingwold the blocks of stone containing *Protocardium truncatum* are much used for paths; they have been extracted in some cases from wells, as near Crayke; but we have not been able to see them anywhere *in situ*. Sandstones, however, are exposed in a small woody ravine near Hanover House, which possibly belong to this series. At Stillington Mill the stream washes a small cliff of shales with small fossils apparently referable to this stage; and from the use of the flaggy limestones in the villages about Sheriff Hutton it is clear that the ridge on which they stand is on these hard beds; but we have not found any ex-

posures; and south of this no indication whatever is given of their existence in Yorkshire.

INLIERS OF THE *margaritatus*-BEDS.

The most considerable portion of the Dales rests upon these rocks. While the Upper Lias skirts the sides, and the *spinatus*-beds run in a narrow line beneath it, the whole of the more level portion is excavated in *margaritatus*-shales or sandstone, not often reaching so low as the latter, and very seldom, as we have seen, passing through them to lower beds. All the minor features of the scenery depend on the excavation or escape from denudation of these rocks: and the terraces they form are very noticeable; in many cases they stand up as flat plateaux, which end suddenly in a steep declivity, the direction of the base of which, though often along the length of the dale, is sometimes transverse to it, in which case the difficulty of conceiving the valley to have been excavated by the stream at its base is greatly increased. The exposures of *margaritatus*-beds are very numerous, and often afford fine liassic cliffs, though not generally very fossiliferous except as to the commoner forms.

Westerdale.—In this dale the chief exposures are in the river Esk near Low Farm, in tributaries to it on both sides of the dale, a fine section in Bagdale Dike, by Westerdale Hall and in the road, in many places along the roadside towards Esklets, also in the eastern head along the stream of Tower Beck—the lower portions of these sections exposing the flaggy sandstones of the series.

Danby Dale.—At the northern end, below Danby Low Moor, the *margaritatus*-shales are seen nearly abutting against alum-shale, the latter being brought down by a fault. The underlying thick-bedded sandstones and sandy shales below continue in a plateau bounded on the west by the stream in many places, in the course of which they can be well seen, rising to the south, till they reach the church, when they are cut off by a transverse declivity and form a prominent and remarkable feature. These beds are fossiliferous. South of this the feature is less decided, but still manifest; and a good section of the shales is seen half a mile to the south, in a wooded stream-course, going down 150 feet, and possibly reaching the level of the *capricornus*-zone. The eastern side of this dale is rather steeper than the western; but nevertheless not many more exposures are seen.

Fryup Dale.—In Little Fryup these may be seen in road-sides and stream-courses, below the ironstone, for which see page 145; but in Great Fryup very little is seen, except at the south, where between Wood Head and Fryup Lodge they form one of these characteristic declivities; and they are exposed, too, nearer the Dale head, and in the deep cutting of High Gill.

Glaizedale.—The Middle Lias covers a small area, which is under pasturage and the plough; so that there is little opportunity of ex-

amination by outcrop, and the *margaritatus*-beds can only be seen (except in the stream, as to be mentioned hereafter) near the head of the Dale, where they are exposed in two or three places in road-cuttings on either side of Hobgarth.

Eskdale.—The upper *margaritatus*-beds are well exposed in the valley of the Esk from below Grosmont, commencing at the Priory, where, in the bank, the bottom seam of ironstone is within view; its course to the east on the south side of the river is traceable by drifts and exploring-levels conducted on it. The beds have an easterly rise; and soon after leaving Grosmont the *margaritatus*-sandstones have emerged from the river-bed and form the steep banks of the Esk fronting Dursley and Spring Woods. The railway-cutting through the latter displays the following section (estimated thicknesses):—

		ft.	
Railway-cutting.	Shale	6	*Am.-margaritatus* zone.
	Stone band	3	
	Sandy marl	10	
	Flaggy sandstone	4	
	Shale	15	*Am.-capricornus* zone.
River-bank	Shales with doggers	30	

In this district the upper 100 feet of the Middle Lias presents a remarkable uniformity; and within its midst are two important rock-beds, which are worked as ironstone. These are the so-called "*Pecten-* and *Avicula*-seams," the lower of which is palæontologically related to the upper *margaritatus*-beds; but from its relation to the main seam of ironstone, it will be treated of therewith.

From near Heckswood the strata begin again to decline; and though on the north side they are thickly covered with Boulder-clay, along the south side (or Eskdale side) they may be traced in cliffs and mine-openings. A fine section of them below any ironstone works may be seen at Blue Scar; they are again exposed on the north side of the river near Sleights Bridge: and a shaft has here been put down, obviously to no purpose; it was carried down 25 feet only. On the other (south) side of the railway, in Iburndale Beck, the *margaritatus*-shales are exposed in a cliff, with 6 inches of ironstone dipping rapidly to the north-east. Nothing more can be seen to the east till in half a mile the Oolite occurs on the level of the railway. In the valley of Iburndale, in the stream-side below Battle Banks, and in day-holes, and on the surface at the neighbouring farm, these shales and ironstone-bands are again exposed, revealing in connexion with the occurrence of the Oolites either an anticlinal or a fault (see "Faults").

Bilsdale.—This dale is deep enough to have its central portion occupied by *capricornus*-beds; and those of *A. margaritatus* form a girdle round it. The exposures are not numerous in the northern part; the chief in the dale are the following:—on both the lanes leading up the hills to N.W. and S.W. of Chop Gate, good continuous sections of sandstones and shales; near Broad Fields; in Hollow Bottom beck; about three quarters of a mile to the south

of this by a stream-side; in the N.E. head of the valley in fine cliffs along the eastern branch of the stream; the hill north of Ledge-Beck bridge is one of the characteristic form; in the road below Studstile; and, finally in the high road by Fangdale Beck. The flaggy beds are here often used for pavements &c. *Margitatus*-sandstones are well displayed in the course of Great Gill, near the farmstead of Ewe Hill in Raisdale, and may be seen also on the road-side leading into Langdale, near High Crosslets; and between Raisdael Mill and West Cote, at the mill, are seen some of the shales.

Bransdale.—The upper marls may be seen in this dale in cliffs along the stream in the western head, and skirting the high ground which divides it from the eastern, especially near the church, below which again the hard bands appear, and thence continue as a mural cliff on the east side of the stream, culminating at an elevation of 100 feet above it, below Groat Hill; thence the terrace declines, and is brought down to the level of the stream by High-Elm House, giving place in a few chains to the ironstone series, which embraces the stream on both sides, till it is lost below the Upper Lias at Catharine House.

Farndale.—Here, as before noticed, the central part is in the *capricornus*-zone, but a very small proportion; so that *margaritatus*-beds are much more spread out here and form characteristic terraces or hills, often flanking the river Dove. The chief exposures are the following:—Carr Wood; characteristic terrace, Sonley Wood; Gill Dike; Hanging-Bank Wood (terrace); cliffs higher up Blakey Gill; Hollin Bush; below Horn End; Kaysbeck; half a mile south of Low Mill, on the Dove.

Rosedale.—*Margaritatus*-beds form a narrow strip along the base of the western head, without any marked exposures till we reach the Abbey, where there are many in the river and by the road-sides leading north and east. South of this they are again seen by the road-side or near it; but they are here dipping rapidly, and the Upper Lias and Oolite succeed.

Palæontology.

The total number of species recorded from the zone is 86, 39 of which make their first appearance at this horizon; but a majority of them pass up to the *Ammonites-spinatus* beds. The restricted species number 16, and are as follows—*Ammonites algovianus, Belemnites Milleri, Chemnitzia citharella, Littorina clevelandica, Discohelix aratus, Dentalium giganteum, Modiola subcancellata, Cardinia prototypa, Gresslya Seebachii, Pleuromya granata, P. concinna, Rhynchonella acuta, Spiriferina Tessoni, Pentacrinus gracilis,* and *Extracrinus subangularis.*

The large accession of species, the profusion of certain others, as *Protocardium truncatum, Cardita multicosta, Ammonites margaritatus, Pecten substriatus, Lima Hermanni, Leda minor, Monotis cygnipes, Rhynchonella calcicosta,* &c., and the peculiar species, some of which

are abundant, as *Dentalium giganteum, Gresslya Seebachii, Modiola subcancellata*, and *Cardinia prototypa*, distinguish the fauna of this zone from that of the *A. capricornus*, with which it has much affinity.

The palæontological distinctions between the lower and upper *margaritatus*-beds are not so great as might be expected, considering the extreme differences of sediment. In each, the majority of the species is confined to certain bands more or less calcareous. In the lower beds we note the following as having therein their head quarters:—*Cryptænia expansa, Chemnitzia nuda, Rhynchonella calcicosta*; and *Dentalium giganteum, Modiola subcancellata, Cardinia prototypa, Pleuromya granata*, and *P. concinna*, which do not ascend higher. In the upper beds occur the following, which are absent in the lower series:—*Cypricardia cucullata, Thracia Grotiani*; and *Turbo cyclostoma, Cardinia lævis, Eucyclus cingendus, Dentalium elongatum*, and *Ceromya petricosa*, which begin here.

List of Fossils from the zone of A. margaritatus.

Ichthyosaurus, sp.
Ammonites margaritatus.
—— algovianus.
—— spinatus.
—— capricornus.
—— fimbriatus.
Belemnites clavatus.
—— apicicurvatus.
—— longiformis.
—— Milleri.
—— cylindricus.
—— breviformis.
Actæonina marginata.
—— ilminstrensis.
Cryptænia expansa.
Chemnitzia Blainvillei.
—— citharella.
—— nuda.
—— ilminstrensis.
Dentalium elongatum.
—— giganteum.
Discohelix aratus.
Eucyclus undulatus.
—— cingendus.
Littorina clevelandica.
Turbo cyclostoma.
Ostrea submargaritacea.
Gryphea cymbium.
Anomia numismalis.
Pecten æquivalvis.
—— substriatus.
—— lunularis.
—— calvus.
—— priscus.
Lima Hermanni.
—— eucharis.
Limea acuticosta.
Plicatula calva.
Monotis cygnipes.
—— inæquivalvis.
—— calva.
Gervillia erosa.
Inoceramus substriatus.
Macrodon Buckmanni.
—— intermedius.
Leda galathea.
—— graphica.
—— complanata.
—— minor.
—— subovalis.
Modiola subcancellata.
—— Thiollierei.
—— scalprum.
—— numismalis.
Protocardium truncatum.
Cardita multicostata.
Cardinia prototypa.
—— lævis.
Cypricardia cucullata.
Astarte striatosulcata.
Hippopodium ponderosum.
Pholadomya ambigua.
Pleuromya granata.
—— concinna.
—— costata.
Arcomya arcacea.
Gresslya Seebachii.
—— intermedia
Ceromya petricosa.
Goniomya hybrida.
Tellina fabalis.
Thracia Grotiani.
Rhynchonella lineata.
—— acuta.
—— tetrahedra
—— calcicosta.

Rhynchonella plicatissima ?
Waldheimia punctata.
Spiriferina Tessoni.
Ditrypa circinata.
—— quinquesulcata.
Eryma, sp.
Ophioderma Milleri.
Ophiolepis Murravi.
Cidaris Edwardsi.
Pentacrinus gracilis.
Extracrinus subangularis.
Clio (?), sp.

CHAPTER XIII.

THE IRONSTONE, OR ZONE OF AMMONITES SPINATUS.

As mentioned in the last chapter, the upper portion of the Middle Lias consists of argillaceous shales with bands of ironstone, some portion of which belongs palæontologically to the zone of *A. margaritatus*, and the remainder to that of *A. spinatus*. We shall find it convenient, however, to treat all the ironstone-beds together; and consequently some details will be given here which might otherwise have been included in the former chapter.

The workable beds of liassic ironstone are entirely confined in Yorkshire to this part of the series; and it is in the N.W. portion of the area that they are most completely developed, deteriorating both in quantity and quality as we depart to the south or east.

The section taken from the ravine of the Skelton beck, near Saltburn, given at p. 134, indicates the relative position and general characters of the ironstone-beds included in that part of the Middle Lias which intervenes between the sandstone-series below and the "Grey Shales" above.

Two bands of ironstone are here conspicuous by their thickness and oolitic structure. The upper one is known as the "Cleveland Main Seam," and is that which is so extensively wrought and the basis of the vast and growing industry on the banks of the Tees. The lower one is called the "Bottom Seam;" and though of fair quality, yet, on account of its comparative thinness, it is not mined in the area of the greater development of the main seam, but acquires considerable importance in the Grosmont district, where it contrasts favourably with that bed. The Skelton-Beck section displays other ironstones, less oolitic in structure as we descend in the beds, all of too small a thickness to attract attention.

We will now examine each of the principal seams in detail, and trace them conjointly over a wide area, after which more particular relations will be indicated.

The Cleveland Main Seam varies so considerably in thickness and character throughout the area of its development, that some particular section must be selected and described as a standard for comparison.

The Main Seam attains its greatest thickness atEston, in the northwest of Cleveland, its most northerly outcrop of which we have certain knowledge. Partaking of the general south-easterly dip

of the Lias, we find it gradually decreasing in quantity and quality in that, as indeed in every direction.

The stone is not, however, of uniform character throughout its thickness, even where it is thick and undivided. Nevertheless it may be described as a lightish-blue earthy rock, porous and oolitic in structure, constituted of carbonate of iron with certain earthy admixtures, and yielding an average maximum of from 30 to 32 per cent. of metallic iron. At its outcrop the stone is a brown hæmatite by atmospheric action on the carbonate.

The differences in the character of the ironstone observable in the Upleatham Mines are well pronounced throughout the other portions of the ironstone-field. Here the main seam is 13 feet in thickness and undivided, but nevertheless exhibits various appearances throughout its mass, not as separable bands, but one structure graduating into the other.

Detailed Section of the Ironstone-series at Upleatham.

Top block or roof, 3 feet thick, consisting of:—

1. A brownish compact argillaceous ironstone with diffused oolitic green grains.
2. Rather more oolitic than No. 1, the argillaceous matter more diffused; small phosphatic particles scattered in the mass.
3. Similar to No. 1, but more oolitic.
   (An average of two analyses of mixed samples of the above gives 27·5 per cent. of metallic iron.)
4. Sulphur bands—a rock composed of oolitic grains, consisting chiefly of iron pyrites. An analysis gives 30·25 per cent. of sulphur, corresponding to 56·71 per cent. of bisulphide of iron.
   (This band was formerly worked at Eston, and applied in the chemical works at Washington, and subsequently at Middlesborough, as a substitute for ordinary pyrites. It generally separates in loose ground from the underlying main block in the process of mining, and when sound makes an excellent roof; but its extreme liability to disintegrate on the action of moist air necessitates caution in placing reliance upon it.)

Workable main seam, 10 feet thick, consisting of:—

5. Top part of main block—a greyish to bluish stone-colour, not uniform, somewhat compact, with pebble-like lumps of an earthy substance of a much lighter colour than the ore, and zinc-blende occupying centres of the more argillaceous parts. Very fossiliferous.
6. Middle part of main block, about 5 feet thick—a light-blue stone, oolitic in structure, but the grains of variable size, with crystals of carbonate of iron and carbonate of lime. The dissolution of the crystals having left cavities in the stone imparts a cinder-like aspect to this part of the seam, by which it may easily be recognized.
7. Lower part of main block—a greenish-blue stone, rather close in texture, and of a finely oolitic structure. A strong parting separates it from the underlying stratum, towards the outcrop.
8. Bottom block of main seam, 2 feet thick—a compact earthy splintery rock of a dark green colour, partaking of the character of a hard mudstone, and perfectly devoid of oolitic structure, which prevails in all the higher parts of the seam.
   (Analyses show it to be rich in alumina and silica, but the percentage of iron does not fall much below the average of that of the main block; it is, however, rejected by most iron-smelters. Fossils are exceedingly rare. It is called by the miners the "black hard.")

9. A bed of shale, 1 foot thick, which underlies, and is called, from the prevalence of *Rhynchonellæ*, which are occasionally aggregated in stony lumps, the "Cockle-bed:" it yields as much as 21 per cent. of metallic iron, the other chief matter being alumina, silica, and lime.
10. Hard shale, 4 feet.
11. Bottom seam of ironstone—a dense blue clay-ironstone, speckled with white and green, 2 feet 8 inches. Fossils not abundant, including *Chemnitzia Blainvillei, Protocardium truncatum, Pecten æquivalvis, Limea acuticosta, Macrodon Buckmanni, Gresslya intermedia.*
12. Shale.

Thus certain regions of the main seam present distinctive characters; and these are indicative of an obscure stratification, certainly so far as regards the portion intervening between the "black hard" and the "sulphur band," which are conformable to the planes of bedding of the higher and lower strata. However, the original stratification is not obliterated, and is prominent in the faces of sections that have been partially exposed to weathering influences.

The stone on the adjoining estate of Thornton Fields is a preglacial outcrop, being now covered with Boulder-clay varying from 60 to 90 feet in depth, and exhibits planes of stratification after the most decided manner. The main block is 10 feet 6 inches thick, and where not too much disintegrated consists of numerous layers of olive-green ironstone, separated by brown partings of oxidized and rotten stone. The number of layers varies from 20 to 30 in the total thickness of the working section, and they occasionally display false-bedding.

A similar phenomenon is observed in the south-west workings of Upleatham and adjacent to the last property. Again, the bared face of the main seam at Belman Bank in the Guisborough Hills presents a like kind of stratification, which is not visible in the sound stone; here the rock is more compact, less oolitic, and approaching the clay-ironstone, and the more argillaceous portions are seen to be arranged in parallel rows, whilst the better parts are gathered around the former as gravelly matter. Similarly the stone at Kildare weathers into a gravelly mass, and ferriferous bosses, having clay centres, arranged in lines.

Something of the character of the ironstone is thus revealed by its mode of weathering. The stone of richest quality breaks up into a *brash*, and as such has been quarried for gravel at several points on its outcrop around the Eston Hills; the sites of these are indicated on the 6-inch ordnance map as gravel-pits. A stone containing more argillaceous material weathers into spheroids with hard compact centres, whilst the intervening portions break up into a gravel. This fact is significant of a more intimate relationship between ordinary clay ironstone and the highly oolitic stone of Eston than at first sight appears.

The thick stone of Eston &c. is vertically joined by a set of divisonal planes coursing in the line of the dip; these are intersected by others which divide the mass into wedge-shaped blocks of large dimensions.

For an account of the origin of the inflammable gas in ironstone workings see Chapter XV.

The joints are generally close, well defined; and the few open joints that have been encountered have clearly been widened by the action of percolating water, traces of which are left in the form of a brown hydrous oxide of iron lining the sides of the fissures.

The stone, from its jointed character and porous nature, is highly permeable to water; but, from the circumstance that it nowhere forms a surface-rock of any considerable area, it is not a water-yielding structure, thereby reducing to a minimum in the exploitation of the ironstone mines the mechanical difficulty of raising water, which otherwise would have been of gigantic proportions. These observations apply, though somewhat in a less degree, to the previous beds of the sandstone-series of the Middle Lias. Indeed the water-supply to the Liassic country is drawn from the Inferior Oolite; and the outflow of water from its base keeps clear of débris its junction with the Upper Lias shale, and materially aids in the preservation of the scarped faces of the oolitic sections by limiting the increase of height of the talus. Were springs discharged from the base of the main seam, it may reasonably be expected that its outcrop would be relieved of its mask of Boulder-clay, which throughout Cleveland generally attains to an elevation a little above that of the ironstone.

Lateral Changes in the Thickness and Character of the Main Seam.

As before stated, the stone has its greatest thickness at Eston Nab, and thence in all directions it diminishes in quality and quantity. In illustration of this phenomenon we give comparative sections of the ironstone-series along the line of the northern outcrop to Huntcliff, then by the sea-coast to the southern limit in that direction of the stone or its representative at Hawsker Bottoms, south of Whitby (see page 124).

In these sections we have taken as the base the upper surface of the "bottom seam," a band which preserves a more uniform thickness and quality over a larger area than the "main seam" does and throughout the northern part of the field is situated at a depth of about 21 or 22 feet below the junction of the Ironstone series and "Grey Shales;" it is also the top stratum of the group of beds which we call the zone of *Ammonites margaritatus*, the overlying set constituting that of *Ammonites spinatus*; so that the sections to which the following remarks have reference illustrate the lithological variations of the strata included under the latter palæontological horizon.

Thus the *spinatus*-beds at Eston consist of 15 feet 2 inches of ironstone, 1 foot 10 inches of a ferruginous shale, and 7 feet of black shelly shales, making a total of 24 feet. This general arrangement obtains to the eastward, certainly as far as Hobb Hill; the only differences notable are the reduced thickness of the ironstone-seam,

Phillips, which displays a limited thickness of shale with two bands of nodular ironstone between the Upper Lias and the rock-bed of the zone of *Ammonites margaritatus.*

Isochthonal Lines of the Ironstone Series.

In the foregoing portion of this chapter we have traced the Cleveland main seam and its associated beds from Eston to beyond Whitby on the south-east, and to the neighbourhood of Thirsk on the south-west, at each of which latter places the Ironstone series of the upper part of the Middle Lias exhibits the greatest poverty in ferruginous matter. A line joining Hawsker and Feliskirk cuts across Rosedale and the lower part of Farndale. These are the only places on it at which the Middle Lias is seen at the surface; and at each of them there is an equal poverty of ironstone, as is indicated by the following sections:—

Section of the Ironstone Series at Hawsker Bottoms.

	ft.	in.
Upper Lias:—		
Sandy shales	2	7
Ironstone dogger and calcareous ironstone	1	9
Hard shales, with five rows of ironstone doggers of an aggregate thickness of 2 feet	29	5
	33	9

For details see *post*, p. 126.

Section of the Ironstone Series at Thor Gill, Rosedale.

Six beds of argillaceous ironstone and doggers, varying from 2 to 5 inches thick, and of an aggregate thickness of 1 foot 7 inches, alternating with hard shale, the whole making about 25 feet.

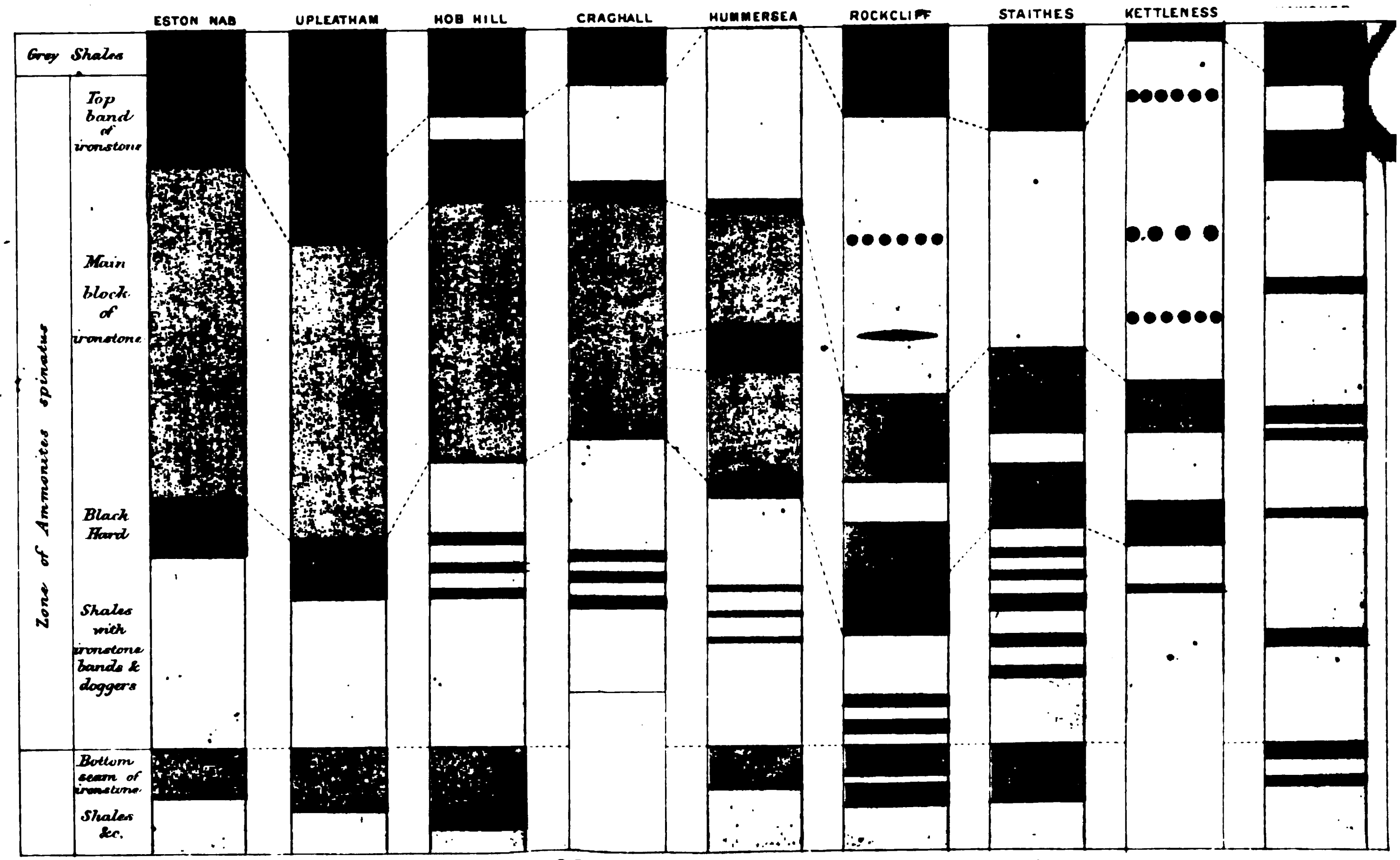
The only section of the Ironstone series in Farndale that we have measured, is near Waces, considerably to the north of the line of traverse from Hawsker to Feliskirk. No complete section was seen on that line; but the limited exposure of the beds intervening between the *margaritatus*-sandstones and the jet-rock, in the lower part of the river Dove, revealed shales with some bands of nodular to ne only. The section near Waces is as follows:—

	ft.	in.
Shale	2	0
Argillaceous stone with ferrous cases	0	4
Soft shale	1	2
Gravelly ironstone, with earthy layer in the middle	1	10
Soft shale	3	6
Argillaceous ironstone doggers	0	4
Soft shale.		
	9	2

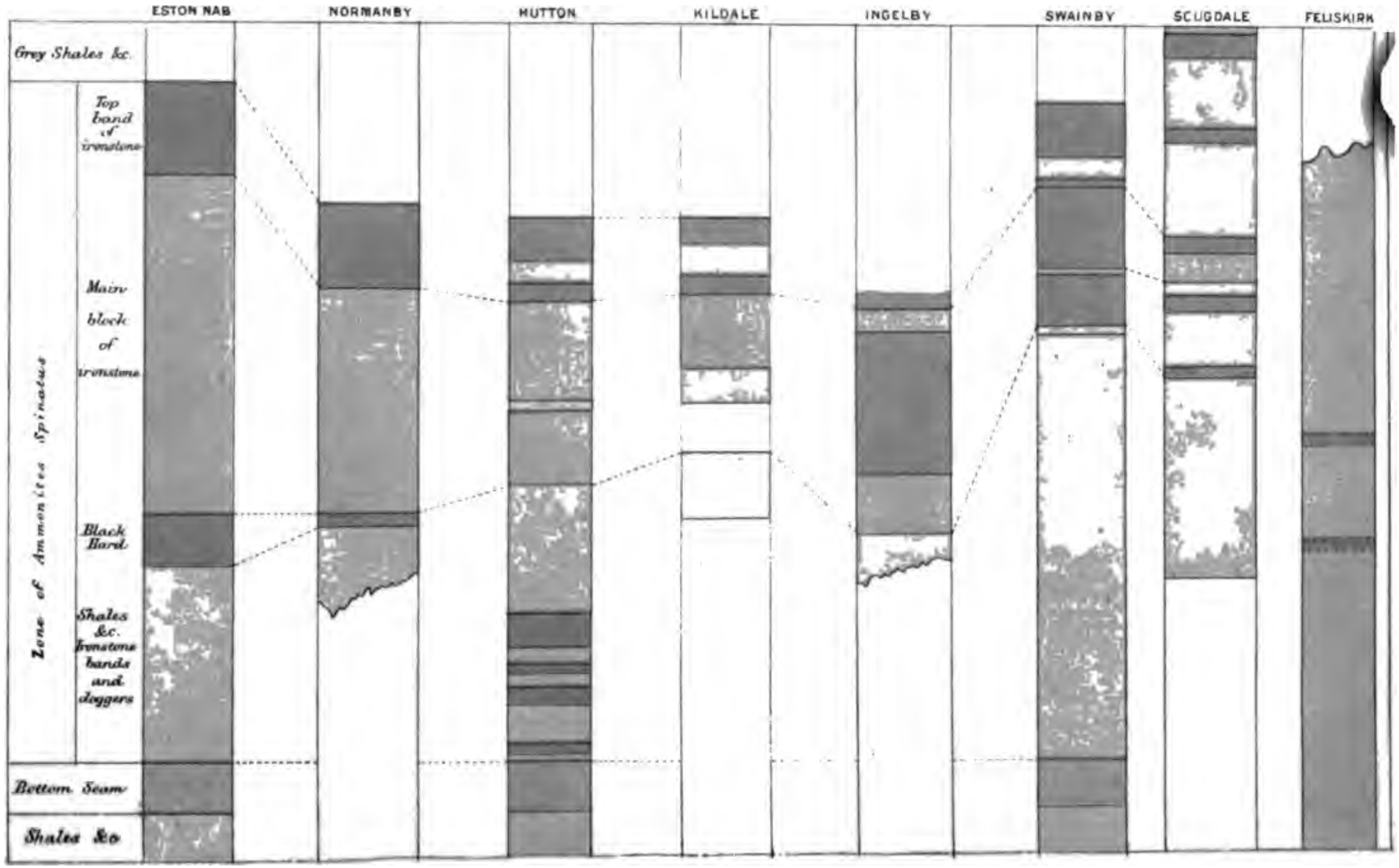
The *Feliskirk section** is:—

Boltby iron rock	7	0
Upper Lias shale	116	0

* J. Phillips, Quart. Journ. Geol. Soc. vol. xiv. p. 96 (1858).



COMPARATIVE SECTIONS OF THE IRONSTONE SERIES.


ESTON NAB
NORMANBY
HUTTON
KILDALE
INGELBY
SWAINBY
SCUGDALE
FELISKIRK
Grey Shales &c.
Zone of Ammonites Spinatus
Top band of ironstone
Main block of ironstone
Black Hard
Shales &c. Ironstone bands and doggers
Bottom Seam
Shales &c

Middle Lias ironstone series :—	ft. in.	ft. in.
Nodular ironstone	0 7	
Soft shale	3 0	11 7
Nodular ironstone	0 6	
Shale	7 6	
Marlstone		1 9
Sandy shale		20 6

Though there is no actual agreement between these sections, yet they establish an important fact, that nearly on the line intersecting them the Middle Lias receives its minimum quantity of iron. This phenomenon was first pointed out by Professor Phillips in the memoir here referred to; and he therein showed that, with respect to the Jurassic series of Yorkshire, lines may be drawn in directions not deviating much from E.N.E. to W.S.W., which shall coincide with bands of equal deposition or equal disappearance of particular sediments and particular distribution of organic life. For these lines, as defining equality of earthy sediments, and thus sometimes marking out similarity of sea-depth and current-action, the author proposes the term "isochthonal," and is of opinion that "the tracing of them will hereafter tend much to increase our knowledge of the physical conditions of definite epochs in geology" (*loc. cit.* p. 97). We shall endeavour to illustrate this subject by special reference to the ironstone, approximately defining its geographical range, indicating the physical condition and depth of the sea-bed, and the direction and proximity of land, and other great characteristics of the period in this part of England.

An isochthonal line drawn through Eston mines has on its north side no ironstone, whilst on its southern side its value grows less and less, as we have shown. The two isochthonal lines which mark out the geographical range of the extremes of mineral condition in the ferruginous series are 16 miles apart, the normals to which are directed approximately to the N.W. and S.E. A true line of section to exhibit the greatest inequality of sediment is therefore a normal to the above-mentioned isochthonal lines, which, commencing at Eston Nab, intersects the outcrop of the ironstone at Hutton near Guisborough, in Kildare, and Farndale only, and meeting the isochthonal line of minimum development in the southern extremity of the latter dale. We have already given comparative sections of the Ironstone series at each of these localities; so that the reader can readily note the successive changes in the mineral condition of the main seam and its associated beds along this line. Another normal through Upleatham affords fuller details than the former, though of course we commence with a thinner band of stone than at Eston; the isochthonal line intersecting the former is a little to the south of that passing through the latter. The sections on this line are furnished by the mine-workings of the Skelton-Park pit, Skelton pit, Slape-Wath pit, and the natural exposures in Danby Dale and Rosedale. Here, again, it will be unnecessary to tabulate these sections for the purpose of comparison, as the results will be identical with those obtained from the coast sections already given,

margaritatus-beds. Nodules 90 feet down are still in the *margaritatus*-shales; so that the shales are correspondingly increased, as they are at Grosmont.

Kettleness.—Proceeding northward the Ironstone series is first encountered rising from beneath the sea-level on approaching Kettleness, where it forms the base of the cliff, the main seam constituting a low mural terrace about 300 yards in length, just above high-water mark. The strata (which are described in the subjoined table) Young and Bird denominated the "Kettleness beds."

Section of spinatus-beds *at Kettleness.*

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	"Grey shales" introduced by black laminated shale. Zone of *Ammonites spinatus*..		
1.	Sandy shale	1 9	
2.	Small argillo-arenaceo-calcareous doggers	1 8 (2–3)	*Pleuromya costata, Pecten æquivalvis.*
3.	Sandy marls		
4.	Black laminated shale	0 6	
5.	Sandy marl	1 1	*Ammonites spinatus, Rhynchonella tetrahedra.*
6.	Sandy argillaceous limestone doggers, with an irregular surface.	0 6	*Am. spinatus, Unicardium subglobosum, Pleuromya costata, Rhynchonella tetrahedra, Pentacrinus amalthei.*
7.	Hard sandy shale...............	4 8 (7–9)	
8.	Dogger-band to 5 inches		
9.	Hard sandy shale..............		
10.	Shale with scattered fossiliferous doggers, gypsum partially enveloping the same; some specimens of Ammonites in blende and iron pyrites	2 0 (10–11)	*Am. spinatus, A. ferrugineus, Chemnitzia Blainvillei, Turbo cyclostoma, Dentalium elongatum, Arcomya arcacea, Inoceramus substriatus, Leda graphica, L. subovalis, L. galathea, Macrodon Buckmanni, Astarte striatosulcata.*
11.	Dogger-band, 3 inches.........		
12.	Shale		*Am. spinatus, Pecten æquivalvis.*
13.	Top block of main seam of ironstone, a subcrystalline calcareous ironstone.	1 9	*Am. spinatus*, and other fossils of the section.
14.	Hard shale.......................	2 4	*Am. spinatus, Pecten æquivalvis, Belemnites microstylus, B. clavatus, B. breviformis*, and others.
15.	Bottom block of main seam of ironstone, a ferro-argillaceous ironstone.	1 6	*Ostrea submargaritacea.*
16.	Hard shale.......................	1 7	
	Total	19 4	

The previous section is depressed below sea-level by a fault coursing at about right angles to the shore southwards along the gully to the west of the village of Kettleness; but the upper strata are brought to view, by a nearly parallel fault, in about 450 yards. From this point to nearly opposite Hob Holes, the marls above the *main seam* occupy the shore, below the level of high-water mark; the ironstone nodules contained in them have acquired a yellow-ochraceous hue, which may explain the designation of "White Stones" applied to this part of Runswick Bay. The *spinatus*-series, on account of their dip towards Runswick village, become covered up by the *annulatus*-shales opposite Hob Holes; and from here to Brackenberry Wyke, near Staithes, the shore-line is chiefly occupied by the Upper Lias; but the shafts at Scarth Hills and at Rosedale Wyke give the position of the main seam below the sea-level.

The section at the Victoria Iron Works, or Scarth Hills, north of Runswick, now abandoned, is given by Marley (*l. cit.* p. 198), as follows:—

Alum shale about 40 feet, to sea-level; below this the company sunk a shaft about 26 fathoms lower, to

	ft.	in.	ft.	in.
Dogger ironstone-band			1	2
Shale			1	9
Top block of ironstone	1	11		
Shale	1	9	7	6
Bottom block of ironstone	3	10		
Shale			1	0
Ironstone			1	0

The same author (*l. cit.* p. 197) has given the following details respecting the ironstone-series at Rosedale cliffs.

	ft.	in.		ft.	in.
Grey shales exposed	12	0	Shale	0	5
Main seam sunk to top block of ironstone	2	9	Ironstone	0	5½
Shale	0	8	Shale	0	4½
Bottom block of ironstone	3	1	Ironstone	0	6
Shale	0	3	Shale	0	5½
Ironstone	0	3	Ironstone	0	7½
Shale	0	3½	Shale	0	3½
Ironstone	0	6	Ironstone	0	5½

Staithes.—On the south side of Brackenberry Wyke the shore-line is paved with limestone nodules enclosing *Ammonites annulatus*; and in juxtaposition may be collected specimens of *Pecten æquivalvis* and other Middle Lias fossils. The fault that is here indicated throws up the *main seam* to just above high-water mark, where, till very recently, it appeared as a low cliff penetrated by two day-levels communicating with the Rosedale Cliff workings, an extensive landslip in the winter of 1872–3 having most completely buried this exposure. On approaching Old Nab the *main seam* emerges from beneath the talus, and at the Nab the ironstone-series from the

bottom stone upwards constitutes a conspicuous terrace, partially submerged at high tide, which runs southward into the reentering angle of Jet Wyke; then, with a considerable rise-dip, the *main seam* gradually mounts the slope of the cliff, and over Staithes has gained an elevation of 150 feet.

The accompanying section of the Ironstone series, taken at Old Nab, differs in a few minor details only from that given by Bewick, forming part of his section of Penny Nab; but as we desired lithological and palæontological characters more in detail, we remeasured the section at a more convenient position for close observation, with the following results:—

No.	Lithology.	Thickness.	Fossils.
	"Grey shales."	ft. in.	
	Zone of *Ammonites spinatus*.		
1.	Black micaceous marly shales with a row of limestone balls.	1 5	*Pleuromya costata, Pecten æquivalvis, Pholadomya costata, Pinna spathulata.*
2.	Laminated shales	0 9	
3.	Friable sandy shales, with limestone nodules at the bottom.	1 6	*Pleuromya costata, Rhynchonella lineata.*
4.	Greyish-brown marly sandstone.	0 6	*Ammonites spinatus, Pleuromya costata, Pholadomya costata, Unicardium subglobosum, Pecten æquivalvis, Modiola scalprum, Limea acuticosta, Protocardium truncatum, Rhynchonella tetrahedra.*
5.	Sandy marl	3 6	
6.	Top block of main seam, surface covered with small branching fucoids.	3 0	*Am. spinatus, Pecten æquivalvis, P. lunularis, P. substriatus, Unicardium janthe, Pleuromya rostrata, Rhynchonella lineata.*
7.	Shale	1 0	
8.	Bottom block of main seam, surface covered with long tortuous fucoids.	2 2	
9.	Shale	0 8	*Pholadomya ambigua, Plicatula spinosa, Ostrea submargaritacea, Rhynchonella lineata.*
10.	Ironstone	0 4	
11.	Shale	0 6	
12.	Ironstone	0 4	
13.	Shale	0 6	
14.	Ironstone	0 7	*Belemnites breviformis.*
15.	Shale	0 10	*B. breviformis, Pecten æquivalvis, Monotis cygnipes.*
	Carried forward........	17 7	

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
	Brought forward.........	17 7	
16.	Ironstone	0 3	*Monotis cygnipes, Arcomya arcacea, Ostrea submargaritacea, Rhynchonella tetrahedra.*
17.	Shale with a ferruginous parting, or narrow ironstone band.	0 8	*Pecten æquivalvis, P. lunularis, Monotis cygnipes, Ostrea submargaritacea, Plicatula spinosa, Rhynchonella calcicosta, Terebratula punctata.*
18.	Ironstone	0 5	*Lima Hermanni, Rhynchonella tetrahedra.*
19.	Marly shale	2 6	*Pecten æquivalvis.*
	Total	21 8	
	Zone of *Am. margaritatus.*		
20.	Bottom seam of ironstone.		For continuation of this section see p. 107.

The Ironstone series is near to the top of the cliff overhanging the village of Staithes on its south-east side; thence it is traceable on the sides of the gully called Gun-gutter and of its two horns, and around the flat-topped elevation, Old Stubble Hill, overlooking the village on the south. From this point its course appears to be a little east of south, as is proved by a boring on the supposed site of Seaton Church, and by the drift of the Rosedale mines, which opens on the surface below Seaton Hill. In the fore-mentioned bore-hole the stone was reached at a depth of 169 feet below a covering of 99 feet of Boulder-clay. The whole of the depressed area which has Dalehouse for a centre is so thickly covered with Boulder-clay that few exposures of any rock are at all known; and these are limited to the stream-courses which unite at Dalehouse: in the two principal western ones are outcrops of the main seam of ironstone. That of the southern one, the Rousby beck, is very limited, and is confined to the south bank of the stream; but that of the northern one, Easington Beck, is traceable for a much greater distance, and affords a good section of the upper part of the series. It is as follows:—

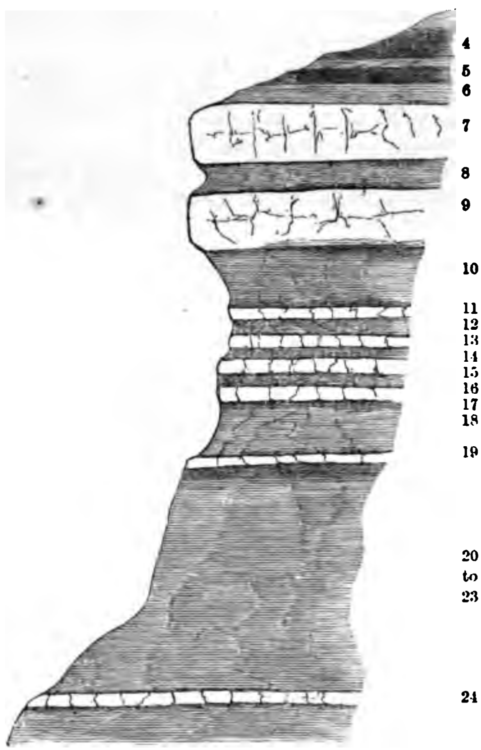
Park-Wood Section, Easington Beck.

	ft.	in.
"Grey shales."		
1. Nodular argillaceous limestone (*Pholadomya costata, Monotis inæquivalvis*)	0	4
2. Sandy micaceous shales	4	0
3. Band of greyish argillaceous limestone..................	0	6
4. Bluish micaceous marly shale	2	1
5. Clay-ironstone doggers	0	2
6. Top block of main seam of ironstone	2	0
7. Hard black shale..	2	4
8. Bottom block of main seam of ironstone	2	3
9. Compact marl.		

The lower part of the section was measured in an exploring-drift driven into the ironstone seam on the north bank of the stream, near by the "foot-bridge;" the stone here forms a conspicuous terrace, and may be traced to the west till it is intersected by the beck. Here a cliff of moderate elevation, on the south side of the stream, has afforded the upper part of our section. This section is an excellent illustration of that general law regulating the distribution of the various mineral matters of the Ironstone series which we have established, as may be judged by comparing it with those of Rockcliff, Staithes, and Kettleness.

From the exposures in Easington Beck to the Boulby Cliffs at Boulby the ironstone is hidden by the Boulder-clay; but several borings in the intervening space give us the course of its preglacial outcrop. The main block of ironstone appears in the face of the cliff at Boulby; and thence the several hard bands in the series form conspicuous crags and terraces (see woodcut), which are interrupted

Fig. 4.—*Section of the Ironstone Series at Boulby.*



by the boulder-covered depression between the western extremity of the Boulby Cliffs and Hummersea, where again the main seam and its subordinate beds form the top of the cliff beneath a capping of clay.

A detailed section of the Ironstone series of Rockcliff or Boulby

Cliff was measured along the footpath on the cliff-face leading down from the hamlet to the shore. It is as follows:—

		ft.	in.
	"Grey shales" passing into		
1.	Laminated shale-like jet-rock	1	9
2.	Friable shale with yellow efflorescence	2	3
3.	Line of nodules (*Pholadomya ambigua*)	0	2
4.	Hard shale	3	9
5.	Lenticular masses of fine-grained sandy limestone	0	8
6.	Ferriferous shale	1	3
7.	Top block of main seam	3	2
8.	Shale with impure ferruginous lumps	1	4
9.	Impure ironstone, 1 ft. 6 in., passing into ferruginous mudstone	4	0
10.	Hard shale	1	11
11.	Argillaceous ironstone-seam	0	6
12.	Hard shale	0	7
13.	Impure ironstone-band	0	7
14.	Shale	0	6
15.	Impure ironstone in two bands } Bottom seam	0	11
16.	Shale } Bottom seam	0	3
17.	Impure ironstone in two bands } Bottom seam	0	9
18.	Hard shale with occasional doggers (*Monotis cygnipes*, *Pecten æquivalvis*)	1	6
19.	Softer shale	3	0
20.	Ironstone doggers	0	5
21.	Soft laminated shale	6	9
22.	Small nodules	0	1
23.	Shale	5	0
24.	Ironstone-dogger seam	0	5
25.	Shale	13	6
26.	Seam of ironstone dogger	1	0

The section of the series at Hummersea, &c., in the Skinningrove mines is:—

		ft.	in.	ft.	in.
	"Grey shales."				
1.	Smooth hard shale			6	0
2.	Dogger ironstone			6–4 in.	
3.	Sulphur band			trace.	
4.	Top block of ironstone	2	0	10	0
5.	Softer ironstone	2	0		
6.	Hard argillaceous ironstone	1	6		
7.	Ironstone of good quality	4	0		
8.	Ironstone inferior	0	6		
9.	Hard green shale, and				
10	Shale with thin alternating bands of iron doggers			5	0
11.	Shale			4	0
12.	Bottom seam of ironstone			1	4

The ironstone seam dips to the southward from Hummersea; and exposures of it, at low elevations, occur on the right bank of the stream a little to the south of the village of Skinningrove. It is not exposed on the west side of the valley, being covered up with Boulder-clay to a considerable depth: and the plateau-like area thence towards Brotton and Huntcliff is similarly encumbered, there being only one outcrop of the ironstone between these points, namely in Cattersty gully. But the operations now being carried on for the exploitation of the ironstone at Carlinghowe and Craghall have furnished the data requisite for the insertion of its outcrop in

the map. The stone is again seen at the verge of Huntcliff; thence for two miles its course is only known by subterranean explorations and borings, and for a like distance it is conjectural. Two outliers of the ironstone are situated to the north of the main mass; these are a narrow strip on the south side of Skelton Beck, opposite to the other one of Hob Hill on its north side. Each of these outliers presents a bold outcrop fronting and overhanging the stream. The steep faces of this ravine have afforded us the section below. The area of the Hob-Hill outlier is accurately defined by the mine-workings, that of the other by borings and drifts, which go far to show that this small patch of stone crowns the crest of the ridge which divides the ravine of Skelton Beck from a parallel one now filled to the top with Boulder-clay. A small outlier of the bottom seam is situated a few yards east of the Skelton-Beck viaduct.

Returning to the main mass, a natural outcrop of the ironstone is by Skelton Beck, situated about 300 yards to the south-east of Upleatham church.

Section of the Ironstone Series, Skelton Beck, Saltburn.

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
1.	Grey shales. ft. in. Hard laminated shale... 0 9 Calcareous shale......... 0 3	1 0	
2.	Main seam— Dogger, a compact argillaceous ironstone with scattered grains, zinc-blende............ 1 3 Dogger, a bluish fine-grained argillaceous ironstone............... 0 9 Sulphur band .... 0 3 Ironstone 9 3	11 6	*Pecten æquivalvis.*
3.	Shale with three iron-bands...	5 0	Seen at the viaduct.
4.	Shale	5 6	
5.	Bottom seam, a finely granular ironstone.	2 9	*Limea acuticosta, Pecten substriatus, Cardinia lævis.*
6.	Shale	18 9	
7.	Nodules of clay-ironstone, showing concentric structure and veined with iron-pyrites.	0 3	
8.	Shale	1 0	
9.	Concretionary ironstone in thin bands, zinc-blende.	1 9	*Arcomya arcacea, Pecten lunularis, Protocardium truncatum, Plicatula spinosa, Pleuromya costata.*
10.	Shale with argillaceo-calcareous ironstone. Dogger at base	18 0	
11.	Soft yellow sandstone	0 10	
	Carried forward.........	66 4	

Section of the [illegible] Series [illegible]—continued.

No.	Lithology	Thickness.		Fossils.
	[illegible]	[illegible]	[illegible]	
12.	[illegible]	[illegible]		[illegible]
13.	[illegible]	[illegible]	[illegible]	[illegible]
14.	Grey sandy micaceous shales	4	[illegible]	[illegible]
15.	Compact hard grey [illegible] sandstone [illegible] Marske Mill [illegible]	[illegible]	4	[illegible] very large [illegible]
16.	Grey micaceous flaggy sandrock.	2	5	[illegible]
17.	Hard ferro-calciferous sandstone.	0	3	[illegible] Pecten æquivalvis, Gresslya, Gryphæa cymbium, Belemnites breviformis.
18.	Flaggy sandstones, and marls with clay-ironstone balls.	2	2	*Gryphæa cymbium, Gresslya Seebachii, Pecten æquivalvis, Rhynchonella lineata, Am. margaritatus, Modiola scalprum.*
19.	Hard blue arenaceous limestone.	0	4	
20.	Yellow sandstone	0	3	*Dentalium giganteum, Monotis inæquivalvis.*
21.	Sandy shales, calciferous sandstone, and flaggy argillaceous sandstones. (The individual beds of variable thickness and degrees of hardness. The harder ones false-bedded, some clay-ironstone nodules in the argillaceous rocks.)	9	0	*Am. margaritatus* (large), *Am. algovianus, Dentalium giganteum, Fucoides undulatus, Cryptænia expansa, Pecten æquivalvis, Protocardium truncatum, Gresslya* (crushed).
22.	Sandy shales.			
	Total thickness	91	11	

The above section is compiled from several stations, though the steep sides of the stream-course present the full series of beds from a little below Skelton Mill to Marske Mill.

The position of the ironstone round the east and north faces of Upleatham Hill, and as far as Throstlenest on the west, is determined by the underground workings of the Upleatham mine. On the west side of the hill an east-and-west fault, with a downthrow to the south, shifts the outcrop to within half a mile of the village of Dunsdale. This fault forms part of the northern boundary to an extensive area of ironstone, which is limited also by a fault on the south. This depressed ironstone-field is thickly covered with Boulder-clay; and in preglacial times the stone formed here a surface-rock of considerable extent, passing under the Upper Lias on the west, but probably separated from the Upleatham stone on the east by a valley excavated to near the level of the lower *margaritatus*-beds, the boundaries of which, however, are not accurately known; nevertheless the numerous boreholes that have been put down leave very little room to doubt the extent of the area denuded of Upper Lias strata, as mapped by us; but the extreme north-western boundary of the field is conjectural.

A section of the stone measured in the workings of the Dunsdale mine is as follows:—

	ft.	in.	
Boulder-clay..............	90	0	Evidently a portion of the dogger or top band has been denuded off.
Dogger-band	0	8	
Main seam	10	6	
"Black hard" at the base.			

On the north side of the Dunsdale fault the line of outcrop is taken up at the exposure on the north bank of Moordale Beck, a quarter of a mile to the south-west of Court Green; thence it leads us northward, the main seam crowning Lovel Hill, thence by numerous exposures to the present outcrop workings of the Eston mines, and westwards to those of Normanby. On the latter royalty, by a complication of faults, there is no outcrop on its north-west boundary; on the south and the east sides, however, it is visible at the surface, and, though much disturbed, may be traced by West Upsall, till it is cut off by a fault coursing from the Upsall sandstone-quarry in a south-westerly direction. This fault is a deflection of the one which extends along the south side of the Eston-Hill range, throwing down the lower sandstones of the Inferior Oolite on its north side to the level of the Ironstone. However, denudation has removed all the Oolite and Upper Lias, and much of the Ironstone on its southern side, a few patches of the *main seam* being left, by which we are enabled to track the line of the fault, and to measure the amount of its throw. The course of the fault continues east, making the southern boundary to the Thornton-Fields estate, previously described, having an outlier of ironstone, that of Tocketts Hill to the south.

In the map, we represent this fault shifting the outcrop of the

main mass of the Ironstone on its south to a considerable distance to the east; but the actual course of the stone between this fault and the Waterfall fault to the south is not known. But the workings of the Skelton mine, situated on the south side of the last-mentioned fault, enable us to insert the course of the stone, which for a considerable distance is covered with Boulder-clay. A roadside-cutting between Spa Gill and Slapewath displays the main seam; thence it is traceable to where it crosses the gill at Slapewath Bridge, there producing a small waterfall.

Slapewath-Mine Section (communicated by W. Charlton, Esq.).

	ft.	in.
Dogger roof	1	6
Top block of ironstone	3	0
Dogger	2	0
Bottom block of ironstone	4	0
	10	6

To the east of Slapewath Bridge the ironstone is covered up with "grey shales" and Upper Lias, which occupy a broad bay in which are situated the mines of Boosbeck, South Skelton, Hazelgate, and Margrove Park, the surface of the ground consisting to a large extent of Boulder-clay and peat, beneath which, in the vicinity of Margrove Park, the Upper Lias has been denuded, as determined by the mine-workings, thus producing an inlier of Middle Lias.

The mine-section at Margrove Park is as follows:—

		ft.	in.
Main seam	Dogger	1	0
	Sulphur band	2	3
	Ironstone	3	6
	Ironstone dogger	1	6
	Ironstone	3	0
		11	3

From Slapewath to Kildale the course of the main seam may be traced almost foot by foot, by the aid of the mining-works to the south of Spa Gill, embracing those of the Branch and Spa-Wood mines; thence by small exposures and other indications we trace the stone with a gradual rise to the south-west to the bared face of stone in the South-Belman and Belman mines.

The railway-cutting at Spa Wood displays a fine section of the bottom seam of ironstone, which contains a profusion of *Gresslya intermedia* in the position of life, and large examples of *Pecten æquivalvis*, *Monotis cygnipes*, and *Lima Hermanni*.

An average section in the Belman mines, as given by Mr. Marley (*loc. cit.* p. 194), is as follows:—

	ft.	in.		ft.	in.
Dogger band........................	1	0	Roof	3	0¼
Shale..................................	0	10½			
Dogger band	0	4¾			
Sulphur band	0	9			
Top block of main seam......	3	5½	Working-section	7	2½
Dogger band	1	11			
Bottom block of seam.........	1	10			
			Total......	10	2¾

Numerous artificial and natural exposures conduct us through Spring and Highcliff Woods to the abandoned mines of Hutton Low Cross; here the Ironstone series consists of:—

		ft.	in.
	"Grey shales."		
1.	Bluish ferruginous limestone in two irregular bands	1	6
2.	Hard shale..	0	9
3.	Thin band of stone, as No. 1.	0	8
4.	Ironstone block	3	5
5.	Shale	0	5
6.	Ironstone block...	2	8
7.	Shale	0	8
8.	Ironstone dogger band	0	4
9.	Shale	0	8
10.	Ironstone dogger band	0	3
11.	Shale	0	3
12.	Ironstone dogger band	0	3
13.	Shale	0	3
14.	Ironstone dogger band....................................	0	6
15.	Shale..i.........	0	3
16.	Ironstone dogger band....................................	0	4
17.	Shale	0	4
18.	Ironstone (bottom seam) with thin shale partings (*Am. margaritatus*, *Lima Hermanni*, *Pecten æquivalvis*, *Monotis cygnipes*, *Pholadomya ambigua*, *Gresslyæ*, *Pleuromya costata*, *Cardinia*, &c.)	3	2
19.	Shale	2	0
20.	Ferro-argillaceous limestone	0	4
21.	Shale	0	2
22.	Ferro-argillaceous limestone	1	6

Hence, by the Hanging Stone, the stone is traced to Roseberry, around which it forms a small ridge and attains to the elevation of 735 feet. By this minor feature which it now makes on the surface of the country, aided by occasional exposures and exploring-drifts, it may be uninterruptedly followed to the Kildale mines. An isolated mass of ironstone, capped by "grey shales," crowns the highest point of Cliff Ridge; it is here partially cut through by the basaltic dyke, which, however, has not penetrated it on the eastern extremity of the ridge, and has in no way changed its outward appearance. The ironstone is seen in close proximity to the dyke in an old quarry near Bank House.

Section in the Kildale Workings (communicated by Mr. J. Hodgson).

	ft.	in.
Sulphur band, irregular, averaging	0	6
Top stone	2	6
Shale	1	3
Bottom stone	1	7
Total of main seam	5	4

The stone still retains some oolitic structure, but seems to be mixed largely with argillaceous matter in lumps, or doggers of variable size. The former part weathers into a gravel, and the latter into brown hæmatite casings, containing clay in the interior, the diffused ferruginous matter of the hard clay ironstone doggers having in the process of weathering transfused to the exterior to form the case or box, the argillaceous portion remaining as a soft clayey mass. The fossils collected here are comparatively few in number, both as regards individuals and species; and none of them are characteristic forms of the main seam. The list includes *Pecten æquivalvis*, *Monotis inæquivalvis*, *Ostrea submargaritacea*, *Gresslya intermedia*, *Protocardium truncatum*, *Limea acuticosta*, *Rynchonella tetrahedra*, *Terebratula punctata*, *Belemnites breviformis*.

From the Kildale mines there is no exposure of the ironstone till we reach the neighbourhood of Ingelby Greenhow; here, on the steep slope fronting Ingelby Moor, on the west, openings have been made on the main seam for a distance of half a mile, including the abandoned mine of Ingelby Manor, situated in Park Plantation. The stone and jet-rock both exhibit a steady rise to the south-west. The section afforded by Ingelby Mine has been communicated by Mr. G. Lee, and is as follows:—

	ft.	in.		ft.	in.
Sulphur band	0	2 to 6 in.			
Top block of stone, superior quality	0	10			
Middle block, a shale full of ironstone nodules	5	0			
Bottom block	2	0			
Total	8	0	to	8	4

We next meet with a trial-opening on the ironstone, immediately on turning south into Bilsdale, on the east side. The vertical section is of limited extent, but reveals a stone of much the same character as that at Ingelby Manor; it contains a few organisms, including *Ammonites spinatus*, *Pecten æquivalvis*, *Monotis inæquivalvis*, *Gresslya intermedia*, *Leda subovalis*, *Pleuromya costata*, *Protocardium truncatum*, and *Macrodon*.

The stone has here attained to an elevation of 900 feet; but from this point it steadily declines to the south along the trend of the valley. In the northern half of the dale the ironstone is almost continuously visible at the surface, from the stone bands breaking up into a ferruginous gravel; it has been opened upon between West Park and Urra.

In the southern half the exposures are less numerous; and south of Stingamire its position can only be traced along the west side, by beds above and below it, though it is said to have been occasionally seen in the stream at its southernmost limit. However, by Beacon Guest, and also about a quarter of a mile to the north of it, some 20 inches of stone may be seen, and the junction with the "grey shales" traced to beneath Stingamire Crag. On the east side, besides several small indications, the following section is exposed at Appletree Hurst:—

	ft.	in.	
1. Shale	2	0	
2. Ironstone boxes	0	4	
3. Shale	1	8	
4. Ironstone (*Pecten æquivalvis*)	1	0	to 1 ft. 3 in.
5. Black shale, with doggers	3	6	
6. Ironstone boxes	0	3	
7. Micaceous shale about	4	0	
8. Fossiliferous ironstone (*Pecten æquivalvis*)	0	8	
9. Shale	3	0	

In Raisdale, which is a confluent valley with Bilsdale, an opening has been made in the main seam at Red Way, on the roadside, descending to the beck. The section is as follows:—

	ft.	in.
Shales (much exfoliated).		
Ironstone, with a layer of ferruginous doggers atop and below. The weathered argillaceous-ironstone balls show much impurity in their mass	2	8
Shale	1	5
Ironstone with a layer of argillaceous ironstone doggers atop	1	9
Shale.		

There is an exposure on the road-side just above High Crosslets: and adjacent thereto an opening has been made into it.

The Ironstone series is readily traceable along the slope of the western side of the northern half of Bilsdale, by various exploring-levels and natural exposures; but no good sections are known to us. It also crops out at the western head of Bilsdale and in front of the oolitic outlier of Cringley Moor, here attaining its greatest elevation of 1000 feet above sea-level, and is well exposed in the steep sides of the beck, below the farm of Staindale, in the northern part of Raisdale.

It is well displayed in the face of the escarpment, which extends from Charlton Moor to Whorlton Moor, and into which trial-openings have been made. It is thrown to a low level by the fault which courses by Swainby across Whorlton Moor, and is mined by drifts at Huthwaite near Scugdale End. Whorl Hill, which is an outlier of Oolite and Upper Lias, presents a steep front to the east; but the slope is not so abrupt on the other sides. Hereon are two conspicuous and concentric terraces: the upper one, at a nearly uniform level of 575 feet, is most certainly made by the jet-rock; the other, at 525 feet, is doubtless formed by the ironstone. There are, how-

ever, no exposures of the stone, though its presence is indicated by the oolitic-ironstone gravel, which reposes on the lower terrace at the northern boundary and adjacent to the wood.

At the north-east entrance into Scugdale the Ailesbury mines show the following sections (communicated by Mr. Bell, resident manager):—

		N. workings. ft. in.	S. workings. ft. in.
	Siliceous dogger	2 0	
	Sandy flaggy shale (roof)	0 10	
α	Dogger	0 2	0 2
β	Ironstone mixed with dogger (top block)	3 0	2 10
γ	Shale	0 2	0 2
γ	Dogger	0 8	1 0
δ	Hard green ferruginous shale (bottom block)	1 2	1 2
	Hard calcareous shale	0 2	
	Marly shale	15 0	
	Ironstone (bottom seam)	1 8	

There is no outcrop till after passing Scugdale Hall; thence the ironstone may be traced as a gravelly terrace to the stream-course, on the west side of which, at an elevation of from 800 to 825 ft., is the following instructive section:—

		ft. in.			ft. in.
	Ironstone dogger	1 0	β	Ironstone	0 11
	Shale	2 7	γ	Dogger with some shale	0 11
	Dogger	0 3	δ	Shale	2 0
	Shale	3 5		Ferruginous dogger	0 4
α	Dogger	0 7		Shale	7 0

The beds in the foregoing sections with the same letters prefixed are considered to be conterminous.

Its range throughout the rest of this dale has been mainly determined by that of the overlying jet-rock, which is extensively mined; but it is laid open to view along the western side as far as the Scarth-Nick fault, having been in past years wrought along a considerable line of its outcrop. We have already given a section of the series in this part of its course, taken from Mr. Morley's paper. The greater development of the stone here as compared with Scugdale Head is consistent with our deductions concerning the south-east attenuation of the main stone.

No exposures are known after leaving Scarthnick, going south, till Mount Grace is reached. Here, on the sloping ground supported by the escarpment of the *margaritatus*-sandstones, are two terraces, one of the jet-rock, the other of ironstone; the latter is traceable, and glimpses of its nature revealed by rabbit-burrows and field operations, as far as Westfield House, near to Osmotherley. A band of ironstone is said to have been proved between the jet-rock at the base of Osmotherley Alum-works and the sand shales of the *margaritatus*-series forming the waterfall in Cod Beck. South of this place the Middle Lias is generally concealed; but the boring made at Feliskirk revealed a much-diminished thickness of the beds

forming the upper part of the Middle Lias, and the poverty of ferruginous matter in this portion of the Lias series (see section).

After passing Thirsk, the next indication of ironstone appears in the railway-cutting just south of Sessay station; the beds are now only exposed in the waterway at the side, but reveal ferruginous sandstones, probably of the *margaritatus*-series, rough irregular stone, not giving any satisfactory indication of ironstone, followed by shales of the *annulatus*-series, and these by jet-rock. The section is only instructive as showing the succession of the beds here; and it can warrant no conclusion, except that the ironstone is not in great force. The junction-line of Middle and Upper Lias running east and west leads us to look for the ironstone as possibly further to the west. Accordingly, on examining a hill visible from this cutting (Barf Hill), we find good indications of it and the probability that it is at least of fair thickness. On the north side of this hill the whole ground is covered with ironstone fragments; but they are at the same time so localized as to afford some evidence of the succession of beds, which is as follows:—

Lithology.	Fossils.
Rough sandy hard shale........................	No fossils found.
Oolitic ironstone and ferrous boxes, 21 paces	*Belemnites paxillosus*, *B. breviformis*, *Pleuromya rostrata*, *Leda galathea*, *Pecten substriatus*, *Cardinia* sp., *Rhynchonella tetrahedra*.
Shale (?) giving no indication on the surface, 25 paces.	
Ferruginous red sandstone, 23 paces	*Lima Hermanni*.

It is difficult to ascertain their dip; but they strike across the slanting hill-side in a direction W.N.W., and are at the extreme end of a tongue of Middle Lias which runs out westward, connected with the before-mentioned exposure of Lower Lias at Topcliffe. An analysis of the upper series of ironstone gave a percentage of 26 of metallic iron.

The ironstone of this tongue is also known at Little Sessay by well-sinkings, whence *Rhynchonella tetrahedra* has been obtained in it. From thence it passes to Easingwold, at the workhouse of which it was met with in a well-sinking, where it was said to be more than 2 feet thick; a terrace below this is probably due to its presence. It was likewise met with, but at a much lower level, in a boring made for coal a little to the east of this, near Haverthwaites House, of which we have been unable to obtain any account. Here it is of a blue oolitic appearance and contains *Rhynchonella tetrahedra*. Ironstone beds of no importance also appear to surround a small outlier of Upper Lias in the same neighbourhood, called Howe Hill. After this no more is seen of it in this district; like all the other beds, if present, it is covered entirely by Boulder-clay.

In the southern area, however, as the various members of the Lias come to be uncovered, it appears again. The first place is

Whitehill Dale, a valley between chalk hills near Millington; and connected with it is an exposure in the next similar valley to the south. Here a blue oolitic ironstone, very similar to that of Cleveland, skirts the road on the east of the stream for some way; it is between 1 ft. and 2 ft. thick, and is interstratified with soft shales; the only satisfactory fossil it has yielded is *Rhynchonella tetrahedra*, which seems to be its most constant companion. It was also met with at a well-sinking in the village of Millington. From the proximity of the Lower Lias in this locality, as well as in other localities to be mentioned, the remainder of the Middle Lias would appear to be here feebly developed, and the upper portion to be its chief representative, till we reach the lowest part, the zone of *A. armatus*.

The next exposure is one near Market Weighton, on the South-Dalton road, a section of which is as follows:—

Lithology.	Thickness. ft. in.	Fossils.
Chalk and red chalk-rubble.		
Marly ironstone with scattered oolitic grains, like bastard stone of Cleveland.	2 6	*Ammonites spinatus, Belemnites breviformis, Ostrea submargaritacea, Plicatula spinosa, Pecten æquivalvis, P. lunularis, Protocardium truncatum, Pleuromya costata, Gresslya intermedia, Pholadomya ambigua, Arcomya longa, Limea acuticosta, Rhynchonella tetrahedra.*
Ferruginous concentric balls with blue limestone centres.	0 4	
Mottled clay	0 6	
Blue clay	1 0	(More unseen.)

These beds are dipping "apparently" to E.N.E.; the ironstone atop, being covered by the chalk débris, may not present its full thickness, but may be denuded.

To the south of this, where the Lias finally parts company with the chalk, the *spinatus*-beds may be pretty continuously traced to the Humber. The slight terrace which it forms running south to Houghton Hall, has its nature revealed at a magnificent spring, the Caldwell, near Sancton. Quite a stream rushes out here from the crevices of a thick rock bed, certainly not less than 3 feet, probably more. We have not succeeded in obtaining fossils from this, as the amount of débris is very small; but there is no mistaking the stone. The large amount of water may be due to the existence of a fault here, which brings down the Upper-Lias clay against it; and moreover the beds dip towards the spring; on the south side of the fault it is met with as a water-bearing stratum at a depth of 30 feet in a village well, a depth due partly to the dip and partly to the throw of the fault. The stone is again seen at a spring feeding the ornamental water of Houghton Hall; but it is not quite certain that this belongs to the same bed as at Caldwell. From

hence we pass nearly three miles before seeing another exposure; and this is an unsatisfactory one—by the road-side leading from South Newbald to Hotham, where numerous ferrous boxes exactly similar to those at South Dalton road occur. A well-marked feature, however, begins here to be formed by it; and in this, near the road leading east from Hotham Hall, the construction of a cistern has enabled us to see the nature of the stone, though no record was kept of the thickness of the beds. Among the débris thrown out are:—1st, strong limestone, the nearest approach to marlstone; 2nd, rather ferruginous sandstone; 3rd, sandy flaggy layers; 4th, blue shale. In the second of these several *spinatus*-fossils occur, *e.g.* *A. spinatus, Terebratula punctata, Astarte striato-sulcata.* But the character of the stone is certainly not similar to that seen in any other locality. In the two springs which occur a little south of this, stone more similar to the usual oolitic ironstone appears. Again, at Everthorpe, as before noticed, Mr. Harcourt long ago recorded the existence of this peculiar oolitic ironstone in a well-sinking, which he compared with the stone on the Dalton road. It is not now to be seen; but we might expect the occurrence of such a stone in the place. It has finally been reported to us as met with in a well-sinking at a farm near Brough.

Inliers of Ironstone.

Westerdale.—On entering this dale from the north the ironstone is encountered, abutting against the Inferior Oolite, which bars the valley on the north, and through a narrow rift in which the river Esk finds a passage to Castleton. Here the stone forms a low terrace skirting the west side of the river Esk from near its junction with Tower Beck to near Low Farm; it has a moderate dip to the north-west. An opening has at some time been made in it; but no section was obtainable; nevertheless blocks of nearly 2 feet in thickness and of a fair average quality had been excavated.

Before approaching Low Farm, a fault with a small upthrow to the south brings the stone into the general slope of the scarped liassic and oolitic range on the west side of the dale. Following the line of the slope, no very certain exposure of the ironstone series is seen till the village is reached. On the northern front of the height called Top End is a considerable plateau constituted of the ironstone and the harder beds of the upper part of the Middle Lias. On this plateau are the "Pits," conjectured by some to be ancient British settlements; these are excavated in the ironstone, which may also be seen cropping out around the church.

Beyond the village on the western side, only partial indications of the stone are seen, forming the base of the slope, till we come to Stockdale, where it forms a low terrace near Park House, and courses of dogger and ironstone are met with at the ford; but very little else is seen of it in this portion of the dale.

On the eastern side of the dale the ironstone is seen at many points; but in no part of its course have we had opportunities

of determining its character and thickness. On its emergence from beneath the "grey shales," towards the head of the dale, it constitutes a low terrace, first acquiring some prominence by Tucker House, thence forming the top of the low cliff bounding the stream on the east, as far as Swarthy and Round Hills; thence it retires from the low ground, its course being then indicated by the position of the farmsteads, till its abutment against the Oolite at the foot of the dale. The sites of the majority of the farmhouses in this dale seem to have been determined upon from the porous character of the ironstone seams, as to a very large extent impervious beds prevail throughout the valley. The same reasons must be assigned to account for the location of the dwellings in many of the other dales.

Danbydale.—Courses of impure ironstone and hard shale occupy the banks of Danby Beck near Smallwoods House; but from the surface being encumbered with débris of vast slips, which affected the overlying rocks around the head of the dale, no clear section can be made out. Ironstone composes the knoll at the back of Nook House; and on the eastern side, about half a mile south of the church, the *margaritatus*-shales are clearly succeeded by others with courses of oolitic ironstone of the *spinatus*-series; but elsewhere the position of the ironstone has been estimated from the presence of the hard black shales which immediately succeed it, and by the outbreak of small springs.

Fryup.—At the head of Great Fryup, in the bed of the stream, below the *annulatus*-beds there are exposed these beds:—ironstone layers 4 inches; shale 6 inches; blue oolitic fossiliferous ironstone, at least 1 foot seen, but being on the bed of the stream its total thickness is uncertain; no more is seen in this neighbourhood, nor generally in Great Fryup; but the low ridge which joins it to Little Fryup is excavated down to the level of the ironstone, which is thus spread out on the surface. The lowest part of the ridge descends to paper-shales belonging in part to the *margaritatus*-series; but the succession may be seen in many spots—nowhere so well, however, as to the west at Slate Hill, where the following roadside section (thickness estimated) occurs:—

	feet.
1. Shale full of smooth brittle iron boxes, unfossiliferous	4
2. Light shaly clay	1
3. Fossiliferous oolitic ironstone full of casts and large *Astartæ*	4
4. Paper-shales with iron boxes, some oolitic, changing at the base to crumbly clayey shales	50
5. Oolitic ironstone without fossils	2
6. Shales with *Am. margaritatus*	12
7. Sandstone.	

Glaizedale.—With this dale we enter upon a district which is exceptional so far as relates to the ironstone series. The peculiar feature is the great thickness of the strata intervening between the "bottom seam" and the "grey shales," and the wide interval

between the two chief ironstone bands—a phenomenon which is foreshadowed in the section at Hawsker Bottoms, and is further illustrated, though wanting definition, by that in Howdale Beck, Robin Hood's Bay.

Over a very large area we have seen that the "bottom seam" occurs at a pretty uniform depth below the *annulatus*-shales; and though the sections from Kildale to Glaizedale would probably exhibit indications of the thickening mass between these levels, yet as they do not admit of examination we are forced to treat the area under present consideration as local. The inference is, that we are upon the margin of a basin which has been filled up to the level of the "grey shales," which spread over it in all directions of a uniform thickness.

The only exposure of the series in Glaizedale known to us is in the course of the beck at its entry into the gorge of West Arncliffe. The succession of the beds in descending order is as follows:—

	ft.	in.
Grey shales with *Ammonites annulatus*.		
Argillaceous ironstone doggers	0	5
Shale	4	9
Argillaceous ironstone doggers (*Protocardium truncatum*, *Unicardium subglobosum*)	0	6
Shale with Belemnites	3	6
Argillaceous ironstone dogger (*Pecten æquivalvis*)	0	4
Shale	1	6
Argillaceous ironstone dogger (*Belemnites* sp., *Pholadomya ambigua*)	0	6
Shale (*Pecten æquivalvis*, *Ostrea submargaritacea*, *Belemnites*)	3	0
Ferro-argillaceous limestone in lenticular masses (*Am. spinatus*, *Belemnites*, *Pecten æquivalvis*, *Macrodon Buckmanni*)	1	0
Hard sandy micaceous shales; portion unseen		
Shales with irregular doggers	2	0
Shale and irregular doggers (8 inches)	3	8
Shale and irregular doggers (8 inches) (*Pecten æquivalvis*)	3	8
Shale	1	2
Ironstone	1	6
Shale	2	3
*Ironstone (dips with the stream, and forms the small waterfall)	3	0
Shale.		

Grosmont.—The *spinatus*-series first appears in the bed of the Murk-Esk, about 40 yards south of the tunnel, and is confined for some distance to the bed and sides of the river, this portion of it (as is seen from the annexed section) consisting of shales and their doggers. The upper workable seam appears a little above the junc-

* This lower band of ironstone represents the *Pecten*-seam, and contains *Pecten æquivalvis*, *Monotis cygnipes*, *M. inæquivalvis*, *Cardinia lævis*, *Astarte striatosulcata*, *Leda subovalis*, *L. galathea*, *Protocardium truncatum*. The *Avicula*-seam which is worked for ironstone at the Glaizedale Ironworks, at a depth of 84 yards, lies 27 ft. 6 in. beneath it.

tion of Lythe Beck, and the lower near Grosmont Hall. The section summarized will read:—

	ft.	in.
1. Shale, and bands and doggers of ferro-argillaceous stone	27	2
2. "Main" or "*Pecten*-seam" of ironstone	4	6
3. Shale and doggers	31	0
4. "Bottom" or "*Avicula*-seam"	3	9
Total thickness...........	66	5

Compared with the sections on the north-west of the ironstone-field, we note the great development of shales above and below the representative of the main seam, whilst the bands of stone containing more or less of ferruginous matter do not in the aggregate amount to the thickness of the main and bottom seams of Eston.

The upper seam is worked at various spots along the southern side of the valley; and several day-holes have been abandoned. On the north side all is deeply covered. The upper seam crosses Sleights above the level of the church, and is probably spread out beneath the village. In Iburndale it dips to the south and east, and is seen rising from the stream beneath the old Alum House of Goathland Banks, where the ironstone is 10 inches thick, but extends no further up the dale. The lower or *Avicula*-seam is worked from a depth of 91 feet on the north side near Grosmont Hall, and at a depth of 231 feet by the side of the railway, half a mile south of the tunnel, and on Eskdaleside nearly opposite Spring Wood, where good sections may be seen. Its further course north is not so well marked; and no certain signs of it occur in Iburndale.

Section of the Ironstone-series of the Middle Lias, Grosmont.

No.	Lithology.	Thickness. ft. in.	Fossils.
	Annulatus-shales with nodules		*Ammonites annulatus, Leda galathea.*
1.	Ferro-argillaceous limestone	0 6	*Belemnites breviformis, Turbo cyclostoma, Pecten æquivalvis, Pleuromya costata, Leda galathea, Limea acuticosta, Macrodon liasinum, Astarte striato-sulcata.*
2.	Hard micaceous shale	3 6	*B. breviformis, Pecten æquivalvis, Astarte striato-sulcata, Unicardium subglobosum.*
3.	Ferro-argillaceous limestone	0 4	*Macrodon intermedius, Unicardium subglobosum, Rhynchonella tetrahedra.*
4.	Shale	2 0	
5.	Ferro-argillaceous limestone	0 10	
6.	Shale	3 1	

Section of the Ironstone-series of the Middle Lias, Grosmont (continued).

No.	Lithology.	Thickness. ft. in.	Fossils.
7.	Ferro-argillaceous limestone	1 8	
8.	Sandy micaceous shale.........	4 4	
9.	Ferro-argillaceous limestone	0 6	
10.	Sandy micaceous shale.........	3 10	*A. lenticularis*, *B. breviformis*, *B. microstylus*, *Chemnitzia Blainvillei*, *Protocardium truncatum*, *Monotis inæquivalvis*, *Unicardium subglobosum*, *Modiola numismalis*, *Limea acuticosta*, *Leda galathea*, *Myoconcha decorata*, *Pecten æquivalvis*, *Gresslya intermedia*, *Ostrea submargaritacea*, *Waldheimia punctata*, *Rhynchonella lineata*.
11.	Oval doggers of argillaceous limestone.	0 6	
12.	Sandy micaceous marly shales with Belemnites.	1 7	
13.	Oval doggers of an indurated calcareous shale veined with zinc-blende.	0 6	
14.	Greyish-blue sandy micaceous shale.	4 0	*A. spinatus*, *Belemnites* (common), *Plicatula spinosa*, *Leda subovalis*, *Pleurotomaria* sp.
15.	Greyish-blue argillaceous ironstone with scattered white grains; gives out a metallic ring under a blow of the the hammer.	1 0	Fossils not abundant and difficult of extraction. *Belemnites*, *Pecten æquivalvis*, *Rhynchonella lineata*, *R. tetrahedra**.
16.	Black hard marly shale speckled in part, upper 2 inches harder and graduating into overlying stone.	1 6	*Belemnites*, *Plicatula spinosa*, *Minotis cygnipes* (common), *Pecten æquivalvis* (com.), *Limea acuticosta**.
17.	Greyish-blue argillaceous ironstone with scattered oolitic grains.	2 0	Upper surface crowded with large *Pecten æquivalvis*, *Belemnites*, *Plicatula spinosa*, *Gresslya intermedia**.
18.	Greyish-blue sandy micaceous shale.	4 0	*Am. margaritatus*, *Actæonina*, *Limea acuticosta*, *Pecten æquivalvis*, *P. substriatus*, *Inoceramus substriatus*, *Macrodon intermedius*.
19.	Ferro-argillaceous limestone with patches of oolitic grains.	1 0	*Protocardium truncatum*.
20.	Hard splintery shale............	3 0	*Limea acuticosta*, *Inoceramus substriatus*, *Pecten æquivalvis*, *Monotis inæquivalvis*, *Pleuromya costata*.
21.	Band of ferro-argillaceous limestone, upper surface mamillated.	0 4	
22.	Hard splintery shale	4 2	to 4 ft. 6 in.
23.	Row of argillaceous limestone nodules.		

* These three beds constitute the so-called "*Pecten*-seam" of this district.

Section of the Ironstone-series of the Middle Lias, Grosmont (continued).

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
24.	Hard blue shale, strongly laminated.	18 0	*Limea acuticosta, Pecten substriatus, Inoceramus substriatus.*
25.	"*Avicula*-seam" so called, consisting of:—		
	a. Bluish argillaceous ironstone with scattered green grains; weathers into balls with concentric hydrous oxide casings, having rottenstone centres.	1 0	*Am. margaritatus, Eucyclus undulatus, Monotis cygnipes, M. inæquivalvis, Pecten æquivalvis, P. lunularis, Plicatula spinosa.*
	b. Shale with Foraminifera	0 4	*Limea acuticosta.*
	c. Nodular argillaceous ironstone weathering into iron-cased balls.	0 4	*Cypricardia cucullata, Ostrea submargaritacea, Mytilus numismalis, Cardinia lævis, Protocardium truncatum, Gresslya intermedia, Waldheimia? punctata, Rhynchonella lineata, Foraminifera.*
	d. Argillaceous ironstone in block, with lumps of bluish-white argillaceous stone and *Gresslyæ* in position of life at the bottom.	2 1	
26.	Blue shale	2 0	to 2 ft. 9 in.
	Nodules of argillaceous limestone.		

Bransdale.—There are a few unequivocal indications of the presence of the representatives of the Cleveland main seam in this dale which have afforded us data for the insertion of the *Ammonites-spinatus* beds in their modified mineral conditions in the geological map. The two following exemplify their lithological characters:—

Section in North-East Bransdale at an old mine.

	ft.	in.
1. Soft shale with fossiliferous doggers containing *Ammonites spinatus*	5	0
2. Gravelly ironstone	1	0
3. Hard shale	1	2
4. Dogger band	0	2
5. Solid ironstone, fossiliferous	1	0
6. Shales with shattered doggers	2	10
7. Irregular doggers	0	3–6 in.
8. Shale	4	3
9. Dogger	0	7
10. Shale	0	8
11. Hard doggers	0	6
12. Shale.		

Section of a stream-course near Catherine House, southern part of Bransdale.—(These beds probably belong to a lower part of

the ironstone series than those in the above section. The upper portion of the section is limited by denudation; and the continuous section is interrupted by a downthrow which brings the upper part of the "grey shales" into contact with the beds under consideration, which are visible in the low banks of the stream. We are inclined to regard them as the equivalents of the bottom seam, and would place them in juxtaposition with the so-called "*Avicula*-seam" and associated strata in the Grosmont district.)

	ft.	in.
Jet rock (slipped).		
1. Sandy shales	1	0
2. Ironstone, oolitic in structure ... 1 ft. 9 in.	1	1
3. Ironstone doggers ... 0 4 (*Astarte striato-sulcata, Belemnites.*)		
4. Shale	2	3
5. Clay-ironstone doggers, fossiliferous (*Protocardium truncatum.*)	0	3
6. Shale	3	4
7. Blue argillaceous ironstone doggers, mixed with shale	1	3
8. Shale	2	4
9. Blue argillaceous ironstone, speckled with white grains	2	3

The characters of the ironstone may also be seen in more accessible places along the north-east portion of the dale as it crosses the road above the church and forms a continuous bank along the eastern side, showing the crumbled débris scattered profusely on the surface.

Farndale.—The occurrence of the ordinary type of the Cleveland ironstone in this dale is proved by the section near the middle head by the stream-side, and by the outcrop of a gravelly ironstone, constituting the crest of a low terrace bounding the stream in the upper part of West Gill, and similar terraces along the north-eastern side, as at Ash House, Hole House, and Head House. The lower part of the river Dove affords an almost continuous section from the Inferior Oolite to the sandstone of the Middle Lias; the beds succeeding to the grey shales consist of shales with ferruginous doggers, without any ironstone seams. The section beneath Middle Head is as follows:—

	ft.	in.
1. Shale	2	0
2. Ferrous boxes with argillaceous centres	0	4
3. Soft shale	1	2
4. Gravelly ironstone with a softer layer in the middle (*Astarte striato-sulcata, &c.*)	1	10
5. Soft shale	3	6
6. Dogger	0	4
7. Shale	20	0

Rosedale.—The only section from which we can determine the general mineral condition of the *spinatus*-beds in this dale is that

exposed in the bed of Thor Gill. Here the junction of the grey shales and ironstone series is well seen, below which the Middle Lias shales and doggers succeed, showing no workable ironstone and a minimum development of ferruginous matter similar to that at Robin Hood's Bay. (For detailed section see p. 124.)

Although it is true that we have here only 25 feet of *spinatus*-beds, whereas at Grosmont 28 feet of shales overlie the workable ironstone, yet we are pretty sure that there is none such in this dale; for on examining two roads which lead from the Abbey (one to Abbey Head the other east to Heygate) the *margaritatus*-beds and the grey shales can be traced very close to each other, and if there were any rock-bed it could not escape notice, more especially in the first, where the thin doggers of Thor Gill are seen crossing the road, and very few feet intervene before we come to *margaritatus*-shales, whose lower continuation into sandstone can be completely traced.

Some writers have indulged in a computation of the extent and probable duration of the ironstone of the Middle Lias in Cleveland; and though our survey would enable us to give an estimate of the area of the seam more accurately perhaps than has hitherto been done, yet we excuse ourselves from the task on the ground that the limits of the seam, commercially considered, fluctuate with its demand. Some stone which found a ready market in the prosperous years of 1872 and 1873, cannot at the present time command a remunerative price. It may be thought invidious in us to fix a boundary between the good and bad stone; of course it cannot be a hard-and-fast line, as the change in the mineral conditions is gradual; nevertheless we do so, and from practical considerations in the mining of the stone and its yield of iron, select the isochthonal line intersecting the Guisborough Hills as the southern boundary of the seam which, under favourable states of the iron-market, is likely to have a sale. As this portion approaches exhaustion, the southern area will gradually be brought more into use—that is, unless other sources of ironstone be introduced to the Tees furnaces.

Schedule of Names of Ironstone Mines and Depths of Main Seam from the surface.

The numbers prefixed correspond with numbers on map indicating sites.

Nos.	Names.	Depths.
1.	Runswick	190 ft., abandoned.
2.	Rosedale	Inclined drift.
3.	Tiverton pit	474 ft.
4.	Whitecliff pit	171 ft.
5.	Lofthouse mines	Worked from outcrop.
6.	Carlinghow pit.	
7.	North Lofthouse pit	213 ft.
8.	Crags-Hall pit	219 feet.
9.	Cliff mine	Worked from outcrop.
10.	Huntcliff pit	„ „

Schedule of Names of Ironstone Mines and Depths of Main Seam from the surface (continued).

Nos.	Names.	Depths.
11.	Brotton pit	261·5 ft.
12.	North-Skelton pit	744 ft.
13.	Long-Acre pit	In progress.
14.	Hob-Hill mine	Worked from the outcrop.
15.	Uplearham mine	„ „
16.	Kirkleatham mine	Inclined drift.
17.	„ . furnace shaft.........	90 ft.
18.	Eston mine	Worked from outcrop.
19.	Normanby mine	„ „
20.	Challoner pit	56 ft.
21.	Tocketts pit	No stone.
22.	„ pumping-shaft	70 ft.
23.	Skelton-Park pit	374·5 ft.
24.	„ or Forty-Pence pit.	
25.	Boosebeck pit	288 ft.
26.	South-Skelton pit	192 ft.
27.	Stanghow or Magra-Park pit	124½ ft.
28.	Haselgate pit..........................	In progress.
29.	Slape-Wath mine....................	Inclined drift.
30.	Branch mine	Worked from outcrop.
31.	Spa-Wood mine	„ „
32.	South-Belman mine	„ „
33.	Belman mine..........................	„ „
34.	Hutton mine..........................	„ „ (abandoned.)
35.	Roseberry mine......................	In progress. Stone at the surface.
36.	Kildale mine..........................	Worked from outcrop.
37.	Kilton pit	680 ft.
38.	Lingdale pit	In progress (about 600 ft.)
39.	Borehole Moorsholme	641 ft.
40.	„ Gerrick	902 ft.
41.	Ailesbury mine, near Swainby ...	Inclined drift.
42.	Glaisdale pit..........................	252 ft.
43.	Esk-Valley pit (S. Cleveland Iron Company).	195·5 ft. to main seam, 231 ft. to bottom seam.
44.	Pit near Grosmont Hall	60 ft. to main seam, 91 ft. to bottom seam.
45.	Mines on the Murk Esk	Worked from outcrop.
46.	Eskdale-side mines, &c.	„ „

General Observations on the Organic Remains of the Main Seam.

The fossils in the main seam are most numerous, both as to species and individuals, in the area of its greatest development. This may be thought to be more apparent than real, because of the greater opportunities for examination and the larger quantities of stone mined in the richer localities than in the inferior ones. But though a larger share of attention has been given to the former, yet the latter have been searched by several workers for some considerable time, and there can be no doubt of the comparative paucity of fossils in them. It may be conceded that a relative paucity of

specific forms is concurrent with the diminution in thickness and quality of the stone. This would seem to indicate that the admixture of argillaceous matter during the deposition of the original calcareous portion exercised some deterrent influence on the animal life within the area of accumulation of such mixed sediment. This view receives confirmation in the distribution of the fossils relative to the lithological characters in the whole extent of the Lias, as all, or nearly all the argillaceous sediments are barren of mollusks of sedentary habits, which are among the dominant forms in the Lias. Ammonites and Belemnites, however, are abundant in the shales; but as they possess great locomotive powers, their presence does not invalidate these conclusions. Nevertheless ordinary bivalves and univalves do occur in some of the shales and clays.

The fossils in the main seam are almost entirely confined to the oolitic portion, and of this chiefly to the upper part of the working section. As a rule they are scattered throughout the mass; but layers of broken and more or less imperfect shells are occasionally met with in the plane of bedding of the stone, and are traceable for considerable distances. So far as we are aware, this evidence of drift-action is confined to the top block of stone. The partially comminuted shells are chiefly rolled fragments of Belemnites, bits of Pectens and Trigonias with fractured surfaces and also worn smooth. In all cases, these fragments belong to endemic species. They indicate the proximity of a shore-line, on which they were reduced to their present condition and by currents carried to their present sites. The occurrence of drift wood, often of large size, in the main seam is a corroboration of the proximity of a coeval land-surface. Mr. George Lee has informed us that a trunk of a tree measuring between 30 and 40 feet in length, branching at the top like a Scotch fir, and having a nearly uniform diameter of about 9 inches, was discovered lying between the dogger band and the main block in the Eston Mine. We have not found any kind of extraneous matter in the seam, not a grain of sand, not a pebble that would indicate a source of the original calcareous sediment.

Certain of the bivalves are generally found with their valves in apposition; these include the Myacidæ (*Pholadomya*, *Pleuromya*, *Gresslya*, *Arcomya*, and *Ceromya*), *Mytilus*, *Astarte*, the majority of which were probably, as their living congeners, burrowers in the limestone ooze; whilst others are invariably met with in the form of detached valves; such are *Pecten*, *Trigonia*, *Cucullæa*, *Avicula*, *Lima*, and *Ostrea*. This circumstance and the fact of the abundance of one particular valve of a given species in one place, and of the other elsewhere, would seem to indicate that some agent was at work to disturb gently the sea-bottom—that, as the ligamental detachments decomposed, the upper-lying valve was caught up by the current and carried away, whilst the other, partially immersed in the sediment, remained.

It is worthy of note that certain species which are common to the main seam and other parts of the Lias, attained their maximum development at the period of its deposition, whilst others in it are

conspicuous by their degenerate forms, evincing a declension of specific energy bordering on extinction. In the former category we mention *Pecten æquivalvis*, often 5 to 6 inches in diameter, *Monotis cygnipes*, 4 inches across, *Pholadomya ambigua*, *Rhynchonella tetrahedra*, *Leda subovalis*, *Pecten lunularis*, and others, some of which are here giants of their race, compared with individuals that lived during the deposition of the earlier stages of the Middle Lias. The converse phenomenon is exhibited by *Protocardium truncatum*, *Cardita multicosta*, *Plicatula spinosa*, *Monotis inæquivalvis*, *Waldheimia resupinata*, which are considerably dwarfed at this horizon.

That part immdediately underlying the "sulphur band" is the principal repository of several species which are normally of small size, including many Gasteropods; ordinary specimens of large-sized species are rare. The chief are:—*Ammonites ferrugineus*, *Pleurotomaria helicoides*, *Pitonellus turbinatus*, *Chemnitzia Blainvillei*, *Cerithium liassicum*, *Actæonina ilminstrensis*, *Plicatula spinosa*, *Monotis inæquivalvis*, *Macrodon intermedius*.

Characteristic Species of the Main Seam.

One hundred different kinds of fossils have been obtained from the zone of *Ammonites spinatus*, 95 of which occur in the main seam of Cleveland.

The species peculiar to this bed are:—*Encyclus conspersus*, *Cryptænia consobrina*, *Tellina gracilis*, *Tornatella chrysalis*, *Ceromya regularis*, *Cucullæa clevelandica*, *Hippopodium gigas*, *Rhynchonella capitulata*, *R. fodinalis*; other species which, though having a greater vertical range in other areas, yet are confined in the Yorkshire Lias to the main seam, such as:—

Pitonillus turbinatus.
Turbo bullatus.
† Arcomya arcacea.
* —— petræa.
† Mytilus aviothensis.
† Hinnites tumidus.
* Trigonia lingonensis.
† Pleurotomaria helicinoides.
† Perna lugdunensis.
† Pleurotomaria rustica.
† Cerithium liassicum.
† Ostrea sportella.
† —— submargaritacea.
* Tancredia broliensis.
† Waldheimia resupinata.
* Speriferina signiensis.
† Rhynchonella acuta.
* Cidaris amalthei.

The species marked with an asterisk (*) are not known elsewhere in Britain; and those marked† occur in the equivalent of the main seam in the Midland and S.W. counties.

The most common species in the main seam are:—

Ammonites spinatus.
Belemnites breviformis.
—— paxillosus.
Pitonillus turbinatus.
Cryptænia consobrina.
Ostrea submargaritacea.
Pholadomya ambigua.
Astarte striato-sulcata.
Waldheimia resupinata β.
Terebratula punctata.
Pecten æquivalvis.
—— lunularis.
Monotis cygnipes.
Macrodon liasinus.
Gresslya intermedia.
Pleuromya rostrata.
Arcomya arcacea.
Rhynchonella capitulata.
—— tetrahedra.
—— lineata.

A complete list of the fossils of the ironstone is given in the Table of species of the zone of *Ammonites spinatus* below.

The number of species obtained by us from the *main seam* so far exceeds those in the cabinets of other local collectors, that some surprise has been expressed thereat. Our success is attributable to our methods of search.

The fossils in the seam at its outcrop have, equally with the stone, suffered great disintegration; so that whereas in an ordinary limestone the weathered rock-surfaces are most favourable for examination for the organic contents, those of the ironstone are unproductive of fossils in even a moderate state of preservation. Should we turn our attention to the blocks of stone as they are brought out of the mine we should be disappointed in not being able to gather other than the larger shells, mainly because of the rubbed and dirtied surfaces; but even otherwise the fossils are so immersed in the stone, and their colour blended with it, that search for them under much more favourable circumstances yields very unsatisfactory returns.

When the stone is stacked or put in stock, the rain washes the surfaces clean, and after an exposure of a few years the shells of many acquire a reddish tinge by peroxidization of the iron which largely enters into their composition; and this change takes place before the general surface has lost its green colour; consequently such fossils are readily discerned by contrast of colour. Our plan has been to crawl or clamber over the old stack heaps at the mines and smelting-works, closely examining the exposed surfaces for the smallest sign revealing the presence of a shell. In this way have been obtained many small fossils which escape detection in the unweathered blocks, however closely they may be scrutinized.

List of Fossils of the Zone of Ammonites spinatus.

Plesiosaurus, sp.
Ichthyosaurus, sp.
Ammonites spinatus.
—— Engelhardti.
—— Holandrei.
—— margaritatus.
—— ferrugineus.
—— solitarius.
Belemnites clavatus.
—— apicicurvatus.
—— vulgaris.
—— cylindricus.
—— paxillosus.
—— longiformis.
—— compressus.
—— breviformis.
—— rudis.
—— microstylus.
Cerithium acriculum.
—— liassicum.
Chemnitzia Blainvillei.
—— semitecta.
Chemnitzia nuda.
Cryptænia consobrina.
—— expansa.
Dentalium elongatum.
Eucyclus conspersus.
—— undulatus.
—— cingendus.
—— nireus.
Nerita alternans.
Pitonnillus turbinatus.
Pleurotomaria helicinoides.
—— rustica.
—— undosa.
—— similis.
Turbo latilabrus.
—— lineatus.
—— cyclostoma.
—— aciculus.
Actæonina ilminstrensis.
—— chrysalis.
Ostrea sportella.
—— submargaritacea.

Anomia numismalis.
Pecten æquivalvis.
—— lunularis.
—— verticillus.
—— substriatus.
Hinnites tumidus.
Lima eucharis.
—— Hermanni.
Limea acuticosta.
—— Juliana.
Plicatula spinosa.
—— calva.
Monotis inæquivalvis.
—— cygnipes.
—— substriatus.
—— calva.
—— papyra.
Inoceramus substriatus.
Perna lugdunensis.
Pinna spathulata.
Modiola scalprum.
—— Thiollieri.
—— numismalis.
Mytilus aviothensis.
Macrodon clevelandicus.
—— intermedius.
—— Buckmanni.
Leda subovalis.
—— galathea.
—— graphica.
Nucula cordata.
Astarte striato-sulcata.
—— rugata.
Lucina pumila.
Cardita multicostata.
Protocardium truncatum.
Cardinia lævis.
Cypricardia cucullata.
Myoconcha decorata.
Hippopodium gigas

Trigonia lingonensis.
Tancredia broliensis.
—— lucida.
—— longicostata.
Tellina lingonensis.
—— fabalis.
Unicardium subglobosum.
Pholadomya ambigua.
—— Simpsoni.
—— lunata.
Goniomya hybrida.
Pleuromya costata.
Gresslya intermedia.
Arcomya arcacea.
—— concinna.
—— longa.
Ceromya bombax.
—— petricosa.
—— sublævis.
Thracia Grotiana.
Lingula sacculus.
Spiriferina Walcotti.
—— signiensis.
Waldheimia punctata.
—— resupinata.
Rhynchonella tetrahedra.
—— lineata.
—— acuta.
—— capitulata.
—— fodinalis.
—— calcicosta.
Ditrypa circinata.
—— capitata.
—— quinquesulcata.
Serpula limax.
Pentacrinus, sp.
Cidaris amalthei.
Rhabdocidaris (spine).
Chordaphyllites cicatricosus.
Nulliporites furcillatus.

CHAPTER XIV.

HISTORICAL SKETCH OF THE DISCOVERY AND INDUSTRIAL APPLICATION OF THE CLEVELAND MAIN SEAM*.

THE unprecedented development of the iron industry in the northern part of the Cleveland district has called forth many claimants for the merit of the discovery of the stone, or its application; and the general desire seems to have been to give the discovery as high a degree of antiquity as possible. Some confusion has been created by writers in the discussion of this subject, by their not isolating those claims which have been made to the discovery and application of the main source of the supplies of our furnaces, from those which have reference to other local stores of ironstone.

The earliest discoverers are considered by some to have been the Romans, by others the monks. But although antiquarians are agreed that iron-works of some sort were established by the Romans, or monks, or both, yet, as the sites of them, excepting the doubtful ones of Westerdale, are in proximity to outcrops of ironstone of Oolitic age, and generally where the Middle-Lias ironstone is not economically developed, as in Bilsdale, Bransdale, Rosedale, Furnace House, in Fryup and Rievaulx Abbey, it is reasonable to suppose that all such ancient or early works have no connexion with the Cleveland main seam or its equivalents; and we agree therefore with Mr. Marley, that these early operations were carried on in the so-called top seams. With respect to the supposed ancient British settlements in Westerdale, which are pits sunk in the main seam of ironstone, a difference of opinion exists as to the use they may have served. Charcoal is said to have been found at the bottom of some of them, which seems to indicate dwelling-places; yet their great depth seems to militate against this idea. On the other hand, there is the remarkable fact of their being excavated on the most considerable outcrop of the ironstone in the dales; and as most other excavations are known to be for some economical purpose, it would seem probable that these were too. Yet the workers would be very foolish to make such isolated vertical diggings, and not carry their operations horizontally as others have done. Though, therefore, we incline to the opinion that these may have been early mining-excavations, we cannot consider the fact conclusively proved.

* The material facts in this article have been abstracted from Marley's paper "On the Cleveland Ironstone," Trans. N. England Inst. Mining Engineers, vol. v., and Bewick's work.

The collection of ironstone on the beach seems to have been carried on from an early date. Mr. Isaac Lowthian Bell* mentions "that for the Whitehill furnace, built in 1745, and abandoned before the end of the last century, ironstone was gathered in Robin Hood's Bay, and that soon after the year 1800 the Tyne Iron Company obtained ironstone in a similar way from the beach between Scarborough and Saltburn." This kind of trade was continued to the year 1848, when the firm of the Witton-Park ironworks collected several thousand tons off the Cleveland coast. It will be conceded that herein there is no discovery of the main seam; and though it is doubtless true that some of the stones gathered on the shore came from the main seam, particularly those from Runswick, yet it is more probable that the bulk of them were clay-ironstone nodules, which so largely abound in the Middle Lias of Robin Hood's Bay and Hawsker, and between Staithes and Saltburn: the ironstone collected from Robin Hood's Bay was certainly of this nature.

The first discovery of the Cleveland main seam of which there is an authentic account was in 1811, when the late William Ward Jackson, of Normanby Hall, had six or eight cart-loads of it, obtained from his property near Upsall, sent to some ironworks on the Tyne, which, however, were rejected as "good for nothing." Also in 1811 or 1812, the late Thomas Jackson, of Lazenby, laid bare the full thickness of the main seam in Lazenby Banks, which now form part of the Eston mines.

Young and Bird (1822) give the true stratigraphical position of the ironstone series, in describing the section of the Boulby cliffs, but do not give detailed measurements, but estimated the ironstone series, consisting of ironstone in beds or rows of nodules interstratified with shale, at 15 feet in thickness.

In 1827 Mr. John Bewick, sen., examined the coast for ironstone on behalf of the Birtley Ironworks, and recommended Kettleness as the most desirable site for commencing operations, on account of the facility with which it could be worked.

In 1829 Professor Phillips correlates the ironstone and sandstone series immediately below the Upper Lias with the marlstone of Northamptonshire. In this section at Kettleness he estimates the alternations of ironstone and shale beds at 20 feet, but does not recognize any industrial value in the series.

In 1836 Mr. Louis Hunton, in his section at Rockcliff, defines the "main ironstone bands and connected blocks of hard ironstone a foot and upwards in thickness, with seams of shale intervening, 25 feet."

In the same year Mr. Henry Belcher, in his Illustrations of the Scenery on the line of the Whitby and Pickering railway, directed attention to a portion of the main seam of ironstone cropping out in the banks of the Murk branch of the Esk at Grosmont.

"It would appear, however, that Mr. Wilson, one of the partners of the Tyne Iron Company, was really the first person to draw attention to the *Pecten*-seam of Grosmont" (Bewick, p. 18).

* 'Colliery Guardian,' p. 265, 1863.

The Whitby Stone Company commenced operations here, and on the 18th of May, 1836, sent to the Birtley Ironworks their first cargo of 55 tons from the so-called *Pecten*-seam, which is said to work easier in the furnace than the bottom seam. A second quantity was received by the same company, but was rejected; however, the stone was again tried; and, finally, permanent contracts were entered into in 1838. These works have been carried on uninterruptedly up to the present time.

In 1838 Mr. Bewick resumed the working of the Kettleness stone, and opened on the main seam at Staithes, for the Wylam Iron Company.

In 1839 Mr. Bewick wrought the main seam at Grosmont, on behalf of Mrs. Clark, for the same company.

In the same year Mr. Nehsham shipped a small cargo of ironstone collected near Coatham (see remarks below) to the Devon ironworks, Alloa near Stirling, for trial.

In 1840, the Messrs. Bewick discovered the ironstone at Skinningrove and at Slapewath near Guisborough.

In the same year the Whitby Stone Company prospected in the north part of Cleveland. The report of the explorers bears the date 10th July, 1840, and is the result of "a reexamination of those parts of the present Eston and Normanby ironstone mines which are alluded to in 1811 and 1812, and by parties fully acquained with the Whitby ironstone" (Marley, p. 183).

The same report alludes to a "2-feet bed of ironstone at East Coatham, of 37 per cent. yield, but only 10 to 15 yards broad, and 200 to 300 yards long." This must be the bed whence Mr. Nehsham shipped a cargo of stone in the preceding year. Mr. Marley's remarks on this part of the report lead one to infer that it is his opinion that the ironstone referred to is not that of the main seam; he writes (p. 183), "This ironstone [*i. e.* the main seam] also rises, and crops out before arriving at Redcar, and does not dip down towards Redcar, as stated in this report." The report, however, states the case rightly, notwithstanding Mr. Marley's observation; a reference to the plan, p. 57, will explain the arrangement of the strata. Here is shown an anticlinal axis to the south of Redcar, with the Coatham beds dipping to the north-west. Though we have not ascertained by actual examination the existence of the main seam on the outer edge of the Coatham Scars, yet as the Off Heights are composed of the hard beds, situated some 70 feet or so below the stone, it may be inferred that the high dip of the beds would bring on the ironstone in the position of the outermost reef, from which the Redcar boatmen assert that ironstone had been collected.

In 1846 Mr. Ord, in his 'History of Cleveland,' quotes from works in which the presence and position of the ironstone are alluded to. His view of the value of the main seam in the northern district may be regarded as that generally held at that time. "It is at present of little value except as ballast, and is scarcely of sufficient importance to encourage speculation."

In 1848 Messrs. Roseby leased the Skinningrove mines, the main

seam in which was previously discovered by one of the lessors, an account of which is given by Mr. Marley. Mr. Roseby being engaged collecting stone from the beach for the Wiston-Park works "observed that some portions of the ironstone in course of shipment were from this seam, and had fallen off the cliffs, and which stone had got worn by the action of the waves of the sea into something like the shape of nodular balls, as well as oxidized into proper colour to pass inspection with the other stone—and, finding such to be the case, was not long in tracing this main bed" (*loc. cit.* p. 184).

On the 26th of August, 1848, 56 tons were despatched to the Wiston-Park ironworks; but the lessors not being able to fulfil their contracts, the mines came into the hands of Messrs. Bolckow and Vaughan, about July 1849, and were worked by them until the 19th of October, 1850, inclusive, when they were transferred to Messrs. Losh, Wilson, and Bell; and from them they passed into the hands of the Messrs. Pease, by whom they are still worked. The main seam may be said therefore to have been now discovered.

Nevertheless the great impulse to the iron-mining operations was given on the opening out of it in the Eston Hills by Messrs. Bolckow and Vaughan in the latter part of 1850. The further application of this discovery was speedy, and in a very few years all the important royalties were taken up, and led to the construction of railways, the influence of the one on the other development being reciprocal.

It appears, then, that Cleveland has been an ironstone-producing district from very early times—that the shipments of beach stones of iron-ore were sent to external smelting works previous to 1800, and down to the year 1848. The merit of the original discovery of the main bed of ironstone belongs to Mr. Jackson, whose endeavours in 1811 to introduce it were frustrated by the prejudices of the ironmasters. Indifferent receptions were similarly extended to subsequent consignments forwarded by others from the more valuable parts of the seam up to a late date. Possibly the mineral did not excite in the minds of any of these gentlemen that confidence in its value which the subsequent labours of the Messrs. Roseby, Bolckow, and Vaughan ascertained it to deserve.

The first attempt to tear up the stone from its bed was by Bewick at Kettleness in 1827, and subsequently in 1838, at the same place and at Staithes; but the exposed character of the coast, and want of shelter, rendered the conveyance of ironstone to the Newcastle furnaces a task of great difficulty and of some danger; and it was therefore not until the stratum furnishing it was discovered in 1836 inland at Grosmont, on the line of the railway, at that time recently opened, that any quantity of the ironstone was consigned to the ironmasters of the Tyne. Despite the facilities for transit, being sent down by rail to Whitby and shipped at all seasons for the Tyne, this first industrial application of the Cleveland main seam did not materially advance the iron-industry, as is proved by the fact that for fourteen years afterwards only two furnaces, and those built under somewhat peculiar circumstances, were

added to the five in blast on the Tyne previous to the importation of this ore.

Obviously the merit of having introduced the iron-industry to the immensely important district it now occupies does not belong to Bewick.

The operations of the Messrs. Roseby at Skinningrove were undoubtedly the first steps to the practical application of the discovery of the main seam in the north of Cleveland, and led to the commercial discovery of ironstone in other localities. The development of these mines, until railway communication was made, was retarded by the mode of transit. The Messrs. Bolckow and Vaughan, experiencing the usual drawbacks of beach-shipping, rediscovered the main seam at Eston near Middlesborough. The success attending their new enterprise was due alike to a fortunate combination of circumstances, as also to the vigour with which they grasped their opportunities, and to them a large share of the merit is due of having laid the foundations of the vast industry centred at Middlesborough.

Chemical Composition.—At the outcrop the stone presents a rich ferruginous aspect; but portions that have been protected from atmospheric influences are of an olive- or bluish-green colour, and the gradual change may be observed in blocks freshly broken. The composition of the ore before oxidization is that of carbonate of iron; but when exposed to the action of moist air it passes into a brown hydrated peroxide of iron. The green colour is due to the presence of an earthy mineral called glauconite, having the general composition of silicate of the protoxide of iron with some magnesia and water, often with other ingredients. It is also probable that the stone owes its bluish tinge to phosphate of iron.

The different physical characters presented by various parts of the seam (described *ante*, p. 119) would lead us to infer differences in the chemical composition. However, a study of the subjoined analyses will prove that the chemical differences are not in kind, but only in the relative proportions of the several substances. These analyses show further that the same part of the seam exhibits some considerable variability in the distribution of the constituent ingredients (compare analyses by Messrs. Crowder and Pattinson)—so much so that we must not place too great reliance upon them as a basis for rigorous comparison. We may, however, safely deduce that the main mass of the stone of the Eston and Upleatham Hills yields an average of 32 per cent. of metallic iron, the greater bulk of the iron existing as a protoxide in combination with carbonic acid. The quantity of silica is about 9 per cent. on the average, ranging as high as 23 at Normanby; it exists in a soluble form, undoubtedly in combination with protoxide of iron, as the green-colouring ingredient, and as a constituent of the argillaceous matter mixed with the ferriferous portions. The percentage of alumina is about 12, and that of the lime very variable; the quantity is probably dependent on the amount of shelly débris in the stone: the average is 2·75 per cent, embracing a range from a trace to 7·35 per cent.,

the Grosmont stone appearing to contain as much as 11·90 per cent. The absolute amount of lime is not high enough to entitle the ore to be called *calcareous*—though, contrasted with the *siliceous* variety occurring at the base of the Inferior Oolite, and known as the "Top Seam," it may be so designated. The distribution of magnesia is more uniform than that of the lime; the various analyses all approximate to the average of about 3 per cent. As it is highly probable that much of the magnesia is an ingredient of the green-colouring matter, the general diffusion of the latter accounts for the uniformity of distribution of the former.

The phosphorus is variable, but has no relation to the quantity of lime, being rather in an inverse than in a direct ratio; its percentage is about 1·5. The phosphates which are disseminated in the ironstone have been derived from the imbedded organisms; and to their unequal distribution may be ascribed the great variability in the quantity of phosphorus.

Traces of sulphur are generally present; and small quantities of manganese have been detected in a few instances.

In addition to the substances mentioned in the Table of Analyses, Mr. Dick* includes in an analysis of Eston stone 0·27 per cent. of potash, and 0·03 of titanic acid. The latter was detected in the residue in the form of microscopic crystals †.

Mr. J. Pattinson, jun., has detected traces of nickel and cobalt. "A quantitative analysis showed that the ironstone contained 0·72 of a grain of nickel and 0·42 of a grain of cobalt per pound. The presence of these metals in the stone was confirmed by their determination in the pig-iron, malleable iron, and furnace-slag, all of which were produced from Cleveland ironstone without any admixture of other ores."

The occurrence of zinc in the Cleveland ironstone had been long suspected, from the deposition of oxide of zinc in the tubes conveying the waste gases from the blast-furnaces in which this ironstone is smelted; indeed it appears that a few pieces of zinc-blende had occasionally been found in the mines, but so rarely as to lead to the conclusion that zinc must be somewhat uniformly diffused throughout the mass of the deposit. This was ascertained to be the case by Mr. J. Pattinson, jun., who submitted a specimen of stone from the Upleatham mines, containing no visible pieces of zinc-blende, to analysis, and obtained a quantity of the oxide of zinc, equal to about 10 grains per ton of ironstone. This dissemination of zinc in an invisible form over a large extent of rock is no longer an isolated phenomenon, as Mr. E. T. Hardman‡ has determined the metal to be widely scattered over a large area of the Hard Chalk in the N.W. of Ireland, but probably as a carbonate.

* "Cleveland Ore." Mem. Geol. Surv. Iron Ores.

† "Some of these, which are white, are quartz; others, which are black and pyramidal, consist chiefly of titanic acid. Prof. Miller of Cambridge succeeded in measuring some of the angles of the crystals containing titanic acid, and found that they corresponded to similar angles in anatase."

‡ Geol. Mag. vol. x. p. 434.

Our experiences of the visible presence of zinc-blende in the Ironstone and associated strata are:—

In the main seam it is chiefly confined to the dogger and upper part of the main block, and is usually associated with the clay-ironstone-like portions, apparently as a nucleus to these ill-defined concentric lumps of more argillaceous stone: in such cases the mineral has an imperfectly rhombic-dodecahedral form; and specimens as large as a tennis-ball have been obtained by us. We do not consider it to be at all rare.

This association of zinc-blende and carbonate of iron is not restricted to the main seam, and has been found to subsist in every possible case throughout the Lias; that is to say, wherever impure limestones acquire a ferruginous property, zinc-blende is developed within them. Thus the clay-ironstone nodules of the Middle Lias and those of the upper part of the Lower Lias, in Robin Hood's Bay, are invariably septariated by the mineral; and in other cases irregular pieces appear in the centre of the masses. Young states that "zinc in the state of blende is not uncommon in these beds [the Kettleness or Ironstone beds], especially in Ammonites and petrified wood; in some specimens of the latter we find longitudinal veins of pyrites intersected by cross veins of blende. The same mineral is also met with in other parts of the aluminous [that is, liassic] strata" (p. 145). We have discovered it also among the limestone nodules of the Upper Lias, but more rarely, and generally only in the presence of some organism. We have found it filling the interior of bivalve shells, and casts of the alveolar cavity of Belemnites in this mineral have been encountered, and also pseudomorphs of *Protocardia* and of some other fossils, in the *margaritatus*- and *capricornus*-beds of Huntcliff, Staithes, and elsewhere.

The form of a compressed branch obtained from the main seam at Hobb Hill, Saltburn, consisted of calcite and lignite, with crystals of blende imbedded in the calcite. From the dissemination of the zinc in the main seam it would seem that it had a contemporaneous origin with original limestone; but the modes of occurrence of visible blende in the ironstone and elsewhere indicate, on the other hand, that the zinc had been introduced subsequently to the deposition of the rocks; and from the fact of its association with the carbonate of iron we are led to surmise that the origins of the two minerals, in their present condition, are related. There can be no doubt as to the formation of the blende within the rock, that it is not of extraneous origin. It is, however, possible that the zinc may have been brought in by the agency of water at a still later period—that is, after the completion of those changes resulting in the formation of the carbonate of iron. But in either case the zinc must have been carried into the rock in some other form than that in which it now exists; its association with organic matter renders possible the opinion that it is pseudomorphic after iron-pyrites.

Tabular View of published Analyses of the Cleveland-Iron Ore.

Description of Ore.	Analyzer.	Silex.	Iron Per.	Iron Prot.	Alumina.	Lime.	Magnesia.	Sulphur.	Phosphoric Acid.	Carbonic Acid.	Water.	Metallic Iron.
Eston (top) oolitic	Crowder	10·90	3·55	39·01	10·62	1·70	3·19	tr.	2·08	25·26	3·69	32·83
,, blue greenstone	,,	11·95	6·73	39·05	13·83	2.52	2·72	tr.	1·02	16·38	5·80	35·10
,, ,,	,,	6·00	3·95	40·85	12·66	tr.	3·19	tr.	2·49	26·16	4·70	34·54
,, dark blue-green	,,	7·65	1·20	43·35	9·88	0·05	5·35	0·09	3·87	22·96	5·07	34·54
,, darker	,,	7·55	...	41·22	14·28	tr.	5·48	tr.	1·02	25·32	5·13	32·06
,, hard stony (bottom)	,,	19·90	1·15	39·50	17·87	1·56	2·31	0·13	2·50	5·54	9·14	28·73
,, green fossiliferous	,,	10·95	2·45	24·93	12·72	8·56	1·80	0·10	1·88	41·54	9·07	21·10
Upleatham (roof)	,,	17·49	tr.	41·00	6·00	3·35	3·70	tr.	0·45	25·70	3·50	31·85
,, floor	,,	20·50	7·00	34·00	12·15	1·40	3·15	tr.	2·55	15·50	5·00	31·36
,, intermediate	,,	14·35	3·50	33·37	8.10	7·55	3·45	tr.	1·50	25·38	2·80	28·42
,, light blue	,,	12·95	2·10	38·43	18·00	2·80	2·10	tr.	tr.	19·18	4·44	31·36
,, soft white stone	,,	7·80	6·50	38·15	11·20	3·35	2·80	tr.	2·70	24·20	3·20	34·30
Eston average	H. Taylor	7·00	...	47·80	6·00	5·80	3·50	...	...	24·90	13·00	36·90
Normanby top 3 ft.	Crowder	23·50	1·43	25·08	3·90	4·56	3·23	...	1·40	22·38	4·52	28·28
,, ,, ,,	Pattinson	15·24	0·47	33·86	6·92	5·82	3·84	0·40	1·40	25·00	3·69	26·66
,, bottom 8 ft.	Crowder	11·95	3·69	39·05	6·41	6·35	3·39	...	1·66	22·29	4·37	32·96
,, ,, ,,	Pattinson	10·30	2·60	38·06	5·92	7·77	4·16	0·14	1·07	22·00	4·45	31·42
Hutton Low Cross (aver.)	Crowder	13·86	2·55	39·72	4·96	4·03	2·18	0·12	2·21	28·10	3·56	30·09
,, ,,	Richardson.	14·00	0·68	42·08	10·40	5·48	1·84	...	...	24·22		33·09
Sleight's Bridge (aver.)	Crowder	9·80	...	42·62	...	...	...	...	...			29·83
Grosmont Tunnel	,,	15·10	...	40·86	...	...	...	...	...		...	28·60
,, *Avicula*-seam	Tookey	15·00	...	33·17	3·92	11·90	4·52	...	0·48	28·00	3·65	25·80

ORIGIN OF THE CLEVELAND MAIN SEAM.

As we have seen that the rock may be described as a carbonate of protoxide of iron, it becomes evident that it could not have been deposited in the sea in its present form; for the protoxide could not fail to be converted into peroxide by the sea-water, on account of its strong affinity for oxygen. It must therefore have been deposited in a different form, and subsequently altered. On this several interesting questions arise. What was its original composition? What changes have taken place? and have we any indication of their nature in the rock itself? Was the iron in the rock in its original state, only in a different combination? or has it been subsequently introduced? It is plain that we must seek the answer to the second question first.

An examination of the composition of the shells of the seam shows that whilst some of them still retain their original composition, almost entirely carbonate of lime, others have changed into carbonate of iron*, which by subsequent atmospheric action has been converted into the hydrous peroxide of iron; it is from this cause that some fossils have acquired that rich ruddy tinge that renders them so conspicuous to the eye of the fossil-collector, on the still greenish surfaces of weathering blocks. The development of colour in shells long submitted to such agency is regarded by us as indicative of the presence of iron, and of the present composition of the shell.

The difference in the composition of the shells is certainly due, in some instances at least, to the original texture of the shell. It will be conceded that, as the shells were originally of carbonate of lime, and are now constituted of carbonate of iron, the iron has replaced the lime. Certain kinds of shells have been more affected than others: these include, among the commoner forms, Ammonites, Cucullæas, Trigonias, Astartes, Ceromyas, and Gasteropod shells, the tests of which are laminated in structure and moderately thin; whilst the thick shells of oysters, and the prismatic tests of Belemnites, Aviculæ, Inoceramus, Pecten, Limas, and Echinoderms seem still to be composed of carbonate of lime. The inference that the more highly crystalline carbonate of lime composing the shells mentioned in the latter category was less affected by external agencies, is quite in accordance with analogous observations. The occasional occurrence of the tests of Ammonites, Trigonias, Hippo-

* Mr. Sorby illustrates such a change in a shell from the inferior oolite of Robin Hood's Bay by the following analysis:—

Carbonate of iron	78·0
„ lime	5·2
„ magnesia	3·1
Peroxide of iron	10·9
Water	2·1
Carbon	0·1
Silica	0·6
	100·0

podiums, and other large shells as pseudomorphs in calcite dces not affect the inquiry.

"The microscopical investigation of a thin transparent section of the stone shows far more clearly that the minute fragments of shell have been similarly altered—the replacing carbonate of iron, extending as yellowish obtuse rhombic crystals from the outside to a variable distance inwards, often leaving the centre in its original condition as clear colourless carbonate of lime, though in many instances the whole is changed. The oolitic grains likewise have such peculiarities as indicate that they were altered after deposition.

"The peculiarities in microscopic structure already described prove that the same change has occurred in the case of a large proportion of the constituents of the Cleveland Ironstone; and according to this view I propose to explain its general constitution. All that is assumed is that it did also in a similar manner affect the more finely grained particles, which do not and could not present such facts as actually prove it to have been so, and yet would be more perfectly exposed to such a process of alteration. The general appearance of the stone agrees remarkably well with this supposition; for when examined with the microscope it is seen to be extremely like many limestones in all such particulars as are compatible with the subsequent alteration being oolitic with small fragments of shells and patches of finer granular matter, as is the case in many oolitic limestones" (Sorby).

Towards the upper part of the main block in the Eston mines we have occasionally found small lumps of unaltered rock, which, from agreeing with the prevailing structure of the ironstone, may be regarded as the stone in its original condition. These lumps consist of a white and greyish chalky paste with imbedded grains, some light-coloured, others green, and mixed with much shelly matter; an identical substance has been recognized filling the interiors of some shells. This material is comparable in its general appearance to the chloritic limestone of the north of Ireland, and with the chloritic marls of the south-west of England.

"Independent, then, of the silica and alumina, resulting from the clay, so commonly found in limestones, and the phosphate of iron, the general composition of the ironstone is very similar to that of the altered shell (compare analyses at pp. 164, 165); so that, as far as the chemical composition is concerned, the same circumstances that must have altered the shell may have changed an ordinary limestone into such a rock in the manner indicated by the microscopical structure to have really been the case.

"The silicate of iron and the phosphate of iron, to which the rock owes its green colour, have been most probably formed by the same process, from the decomposition of the phosphate of lime so often found in limestones, and the silicate of alumina of the clay; for phosphate of iron is produced by the action of bicarbonate of iron on phosphate of lime, and many facts indicate that the silica of the silicate of iron could be thus derived, either by the direct

replacement of the alumina of the clay by the oxide of iron, or by the decomposition of silicate of lime. This does not occur in some limestones, and may have been formed from ordinary clay by the action of the sulphate or hydrate of lime, which are met with in recent limestones and coral reefs" (Sorby).

Mr. Sorby concludes that the Cleveland stone was a kind of oolitic limestone interstratified with clays containing a large amount of oxide of iron and organic matter, which, by their mutual reaction, gave rise to a solution of bicarbonate of iron—that this solution percolated through the limestone, and, removing a large part of the carbonate of lime by solution, left in its place carbonate of iron—and not that the rock was formed as a simple deposit at the bottom of the sea.

CHAPTER XV.

ZONE OF AMMONITES ANNULATUS.

THIS subordinate member of the Lias, described by Young and Bird (Geol. Surv. p. 142, 1828) as the Hard and Compact Alum Shale, is one which has been fully recognized in its lithological characters by the sinkers and miners in Cleveland.

The rock is a micaceous sandy shale of a coarser texture than that of the higher and lower beds—hard, compact, and bluish grey where protected from atmospheric influences, but crumbling into small subrhomboidal fragments of a greyish colour in exposed situations. Thin sandstones occur in the lower part of these beds, as exhibited in the banks of the Murk Esk, at Grosmont. It is very regularly prismatically jointed, as may be seen at Hobb Hill, near Saltburn, West Upsall, south side of Eston Moor, in West Arncliffe, Glaizedale, &c. Rows of ferrugineo-argillaceous limestone balls of inconsiderable size occur at irregular intervals throughout the zone. These balls are extremely hard, and of a dark iron-grey colour when unweathered, but after long exposure show an outer ferruginous casing or box with a soft arenaceo-argillaceous mass within. Large masses of a blue septariated hydraulic limestone are to be seen in the section at Glaizedale.

The majority of the balls are unfossiliferous; but an example may occasionally be found to contain many of the smaller species recorded in the list of fossils. However, nearly every nodule forming a band towards the middle part of the zone contains either one or two specimens of *Ammonites annulatus*, or the alveolus of a Belemnite, the guard projecting from the nodule and resting on the shale. These ammonitiferous balls are exposed on the flat shore in Runswick Bay, opposite Hob Hole, and in Blackenberry Wyke, south of Staithes, as also in various cliff-sections on the coast and inland.

The "grey shales" present such physical characters as readily serve to distinguish them from the Jet Rock or Alum Shale, but have close agreement with the shales forming part of the Ironstone-series of the Middle Lias; however, the smoothness and darker colour of the latter, and more especially the distinct species of Ammonites in each, will enable one to separate them. The practical value of this knowledge is not to be underrated; and we know that in two instances a search for the Cleveland main seam has been prosecuted in the lower shales of the Middle Lias, in the belief that

they were "grey shales," despite the palæontological evidence to the contrary.

The rock is economically unimportant. The zone is remarkably constant in mineral character; and although a comparatively thin stratum, yet it is very persistent throughout Cleveland. Its thickness, which averages 30 feet, has been determined at the following localities:—

Hawsker	36 feet.	Eston Nab	33 feet.
Staithes	40 „	Cod Hill, Guisborough	30 „
Rockcliff	31 „	Whorlton Hill	25 „
Hob Hill	31 „	Glaizedale	25 „

Section at Hobb Hill (continued from p. 135).

	ft.	in.
Jet Rock.		
Sandy shales, about	16	0
Round doggers .... } Sandy shales .... }	2	4
Round dogger, *Ammonites annulatus* and other fossils .... } Sandy shales .... }	4	6
Small doggers.. } Sandy shales .... }	4	11
Ferriferous nodules, *Astarte* &c. .... } Sandy shales .... }	3	0
	30	9
Ironstone Series.		
Hard laminated shale	0	9
Rotten calcareous shale	0	3
Dogger of main seam.		

The line of junction between the Ironstone series and the grey shales is strongly marked in the north-west of Cleveland, no greater contrast than between the argillaceous beds of the *annulatus*-zone and bright greenish-blue of the massive ironstone can well be conceived. In the preceding Chapter we have drawn attention to the development of shales above the main seam in all directions from Eston, slight indications of which are exhibited in the foregoing section. These constitute a lithological transition between the two zones; and examples of such gradations as at Staithes, Kettleness, Grosmont, &c. have been fully referred to. In these cases the line of demarcation between the two formations has been hitherto drawn less upon palæontological than upon lithological differences. As the "grey shales" of the Ironstone-pit sections comprise all the shales intervening between the Jet rock and the Cleveland main seam, so their thickness is falsified by that of the shales, which seem to belong to the *spinatus*-series. At Grosmont they are 27 feet thick.

Section at Rockcliff (continued from p. 133).

	ft.	in.
Jet Rock.		
Grey shale, estimated	15	0
Hard ferruginous shale, making a strong line in the cliff (*Am. annulatus*)	0	8
Grey shale	1	1
Paper shale (like Jet rock)	0	9
Sandy shale	2	3
Line of doggers	0	3
Sandy shale	0	11
Line of doggers	0	2
Sandy shale	1	5
Line of oval doggers	0	2
Friable shale	0	11
Line of oval doggers	0	2
Friable shale	1	4
Line of oval doggers	0	4
Sandy shale	1	9
Line of cylindrical doggers, Belemnites	0	1
Sandy shale, passing into :—	3	6
	30	9
Spinatus-series.		
Laminated shale	1	9
Friable shale	2	3
Dogger (*Pholadomya ambigua*)	0	2
Hard shale	3	9

The exposures of this zone are numerous; and as its range almost universally conforms with that of the *spinatus*-zone, it is not necessary to enter into details connected therewith. At the Peak it is seen on the seashore without rising into the cliff. In Howdale Beck its exact relation to the beds above and below is seen in the gorge-side. It is conspicuous in the Hawsker cliffs, and descends to the seashore at Hawsker Bottoms.

It emerges from below high-water mark on approaching Kettleness, where it occurs a little up in the cliff, but sinks below the surface at the south-west corner of the Bay. It occupies the shoreline between Port Mulgrave and Brakenberry Wyke, where it is thrown up into the cliff, and may be well studied at Old Nab, and again on the high ground over Staithes. It is exposed in Park Wood, on the banks of Easington Beck, is well seen along the front of Boulby Cliffs, is visible in the railway cutting at Huntcliff, at side of Hobb Hill, and the scarped face of the Upleatham, Eston, and Normanby mines, at Slape Wath and Cod Hill (near Guisborough), at the Kildale mines—though not well seen in the Stokesly hills, yet is recognizable in the outlier of Whorlton, the most southern exposure of the *annulatus*-beds in Cleveland, though undoubtedly present further south, as may be inferred from the interval between the *main seam* and jet rock.

The series is typically developed in West Arncliffe, Glaizedale, at Blue Bank, between Egton and Grosmont, and in the banks of the Murk Esk at Grosmont.

These shales are not clearly shown in Bilsdale or Raisdale; but there is a good section of them with their characteristic Ammonite in Bransdale, in the banks of the beck by Catherine House, as also in Farndale, in the course of the lower part of the river Dove. In Rosedale they are well displayed in Thor Gill; and here their stratigraphical position is clear.

In the Sessay cutting (before mentioned) these shales follow the *spinatus*-beds, and show their characteristic appearance and Ammonite. Shales occurring on the hill-side at Easingwold, past the Workhouse, appear to belong here. After these scattered exposures the only other occurrence we can mention is in a well-sinking at Millington, near Pocklington, the zone not being otherwise known south of the overlap of the Oolite and Chalk.

Palæontology.

We impose on the lithological horizon of the Grey Shales the palæontological cognomen of the zone of *Ammonites annulatus*, from the circumstance of the great abundance of this Ammonite, first noted by Hunton (Trans. Geol. Soc. 2nd ser. vol. v. p. 215). It is moreover the only species of the genus at all common, and, so far as we are aware, is confined to this stratum.

Fossils are not abundant, excepting some two or three species, and unless when contained in nodules are mere shelly films or are so crushed as to render their specific determinations extremely unsatisfactory. The majority are located towards the base of the series; but all the quoted species have been found associated with the dominant Ammonite; most of them are of small size; and their imperfect preservation will account for the reputed barrenness in fossils of these "Grey Shales."

The subjoined list of species contains more Middle-Lias than Upper-Lias forms: the facies is most decidedly medioliassic; the characteristic Ammonite belongs, however, to an Upper Liassic group. From our knowledge of the fauna we do not hesitate to include the "grey shales" in the Middle Lias; though the expediency of such a course may be doubted, as it disturbs without much gain the classification applied to external districts. Of the two arbitrary lines which could be drawn in Yorkshire, separating Middle from Upper Lias, that at the base of the Jet rock accords more with the palæontological features than the one at the base of the *annulatus*-shales. The fossils of the Jet rock, which, however, are few in number as regards species, are either peculiar or pass up into the Alum Shale; they are decidedly Upper Liassic. In the Midland and south-west counties the intermingling of well-marked Upper-Lias forms in the top bed of the *spinatus*-series is rather a converse phenomenon to the one indicated for the Yorkshire transition beds. *A. spinatus* and *A. communis* occur together in the ironstone around Banbury, and in the rock-bed of the Middle Lias in Dorsetshire; but *A. annulatus* is associated with *A. bifrons* and other Upper-Lias species in the *Leptæna*-beds of Ilminster. Thus, while this palæontological

overlap occurs in the equivalent to the Cleveland main seam in the southern and midland counties, in Yorkshire it is restricted to the overlying "grey shales;" a single specimen of *Ammonites Holandrei* in the ironstone at Hob Hill, of the vast multitude of individual forms, can alone claim an Upper-Lias home.

List of Fossils from the zone of Ammonites annulatus.

Ichthyosaurus, sp.
Ammonites annulatus.
—— concavus.
—— margaritatus.
—— cornucopia.
—— semicelatus.
Belemnites cylindricus.
—— latisulcatus.
—— breviformis.
—— pollex.
—— validus.
—— striolatus.
—— scabrosus.
Actæonina tessellata.
Chemnitzia Blainvillei.
—— acicula.
Cerithium liassicum.
Dentalium elongatum.
—— liassicum.
Eucyclus cingendus.
Pitonillus turbinatus? (cast).
Turbo cyclostoma? (cast).
Astarte striatosulcata.
Monotis inæquivalvis.
—— papyria.
Protocardium truncatum.
Macrodon intermedius.
Cypricardia cucullata.
Goniomya hybrida.
Gresslya intermedia.
Inoceramus dubius.
Leda galathea.
Lima galathea.
Modiola numismalis.
—— scalprum.
Nucula subglobosa.
Pecten substriatus.
—— æquivalvis.
Pinna spathulata?
Pleuromya rotundata.
Pholadomya ambigua.
Unicardium subglobosum.
Rhynchonella jurensis.
Extracrinus briareus.
Coleopter (elytron).

CHAPTER XVI.

JET-ROCK SERIES, OR THE ZONE OF AMMONITES SERPENTINUS.

Such is the palæontological designation given by us to the series of beds which occupies the lower portion of the Upper Lias, and lies above the *annulatus*-shales (just described) and beneath the rocks containing *Ammonites communis* and *A. bifrons*. From the occurrence in them, however, of jet, it is more common to call them, in Yorkshire, the Jet-rocks; but this, though convenient, is to a certain extent misleading, because we are obliged palæontologically to include beds in the zone which do not yield jet, this last property being quite a local and accidental one. The presence, however, of the zone inland is commonly indicated by the workings for jet; and thus, though its exposures are numerous, it is generally only one portion that can be seen. The series consists at the top of hard smooth friable shales of a light colour and slaty appearance, succeeded by strong compact bituminous shaly rock, often sulphurous, running into hard stone bands, or large lenticular masses like huge cheeses, and containing jet in the interstices between the layers, in thin outspread masses. The hardness, blacker colour, and odour (when perceptible) of these shales will always distinguish them from others; and, owing to their compactness, the very minute laminations are often very clearly visible.

The Jet shale, though excessively hard and compact when first mined, soon breaks up on exposure to the atmosphere into exceedingly thin laminæ of a brownish colour, whilst the overlying Alum shale crumbles into powder with a yellow-white exterior.

These shales are in places so highly impregnated with iron pyrites and bitumen that spontaneous ignition is not of infrequent occurrence; such natural fires have been burning for years at Staithes, Lofthouse, &c. A piece of bituminous shale gives out a clear white light when put into a bright fire; and the quantity of oil that may be extracted from one ton of the shale is computed at ten gallons.

The nature of the Jet shales gives a clue to the origin of the inflammable gas which is not unfrequently met with in jet mines, in pit-sinkings in the rock, and in the ironstone mines. The workings of ironstone mines near to the outcrop, or where the solid jet rock does not form a part of the cover, are free from gas; but in the majority of the mines the jet-shale makes a part of the roof, and in them gas is present in more or less quantity; in some it issues from between "backs" of stone in such considerable jets as to be burnt.

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—— breviformis.
—— pollex.
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—— striolatus.
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Monotis inæquivalvis.
—— papyria.
Protocardium truncatum.
Macrodon intermedius.
Cypricardia cucullata.
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Gresslya intermedia.
Inoceramus dubius.
Leda galathea.
Lima galathea.
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—— scalprum.
Nucula subglobosa.
Pecten substriatus.
—— æquivalvis.
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Explosions occasionally occur, though rarely serious. The gas is obviously a distillate from the bituminous shales, which escapes to the atmosphere upwards through a light cover; but when this is impossible, it finds its way readily by way of the joints in the *annulatus*-shales and ironstone to the exterior. In the Tiverton pit-workings liquid bitumen drips from the fractures in the top block of stone, and exudes through it, as indicated by the discoloured patches on the pillars, like the moisture out of a newly plastered wall.

The upper beds of this series pass gradually into the overlying *communis*-shales, there being at that horizon no very clear lithological distinction. The change into the *annulatus*-beds below, however, is more marked.

The nodules of the jet-rock have their peculiarity; they are generally of an oval flattened shape, sometimes of irregular form as if two had been welded together, and of various sizes; they are all highly charged with iron-pyrites, which is concentrated in a band near the outside and extends more or less into the interior, in which if there be any cavities, they are filled with liquid bitumen. These nodules are surrounded by an earthy band when decomposing.

The best locality for the study of these rocks is on the sea-coast, where their succession is not obscured, although at some inland sections, *e.g.* Fryup, they may be fairly traced. At the south of Whitby, near Saltwick Nab, we have the following series:—

No.	Lithology.	Thickness.	Fossils.
		ft. in.	
1.	Blue shale with numerous flattened fossils.	10 0	*Belemnites tubularis*, *B. dorsalis*, *Ammonites elegans*, *A. serpentinus*, *A. heterophyllus*, *A. delicatus*, *Inoceramus dubius*.
2.	Large lenticular doggers, sulphurous (the "cheese" dogger).	0 10	*Inoceramus dubius*, *A. elegans*.
3.	Blue hard semibituminous shale.	16 0	*Posidonomya Bronnii*.
4.	Solid continuous indurated band of hard sulphurous shale ("animal" dogger).	1 0	Few fossils. *Inoc. dubius*, *Gyrosteus mirabilis*.
5.	Hard blue very bituminous shale (jet-rock).	20 0	Fish, reptiles, &c. *Posidonomya Bronnii*.
	Soft rotten shales of the *annulatus*-beds.		

The total thickness here is, therefore, reckoned at about 47 feet, but is probably somewhat more. The actual thickness of the zone varies with the other beds; and when fully developed it reaches from 50 to 60 feet. Of the two named doggers, one is called the "cheese" dogger, from its appearance; the other the "animal" dogger, from

the fish-remains contained in it; and it is below this that jet is plentiful: between the two it is less so; and above the "cheese" doggers there is none. The most characteristic fossil of this series is *Inoceramus dubius*; there is scarcely ever an exposure of these rocks to be seen, but on one of the fragments fossils occur. Compressed specimens also of *A. complanatus* and *A. serpentinus* occur over all the beds. *Posidonomya Bronnii*, which cannot, we think, be considered identical with *Inoceramus dubius*, though so stated by Prof. Phillips, is a far rarer shell, and easily distinguished.

Range and Exposure of the Jet-rock Series.

The Jet rock begins to rise to the sea-level a little to the south of the Peak fault, and forms the upper part of the beach-line till cut off by it. Here the "cheese-doggers," measuring 4 to 5 feet in diameter, like thin-edged millstones, are elevated above the general level, on cones of shale, which, being softer, is washed away all around them. A less-fine assemblage of these tables may be seen on the shore near Saltwick, and between Sandsend and Kettleness. The shale beneath the doggers is covered with the black guards of *Belemnites tabularis* and *B. dorsalis*, glistening among which are bright pyritous casts of *Ammonites elegans*, *A. serpentinus*, *A. gracilis*, and *Inoceramus dubius*.

On the north side of the fault they may be seen again in full force in the lower part of the gorge of Howdale Beck. They may be easily recognized at Hawsker Bottoms, on the cliff-side, by the numerous holes dug into them, gradually descending from the top near Castle Chamber, to the shore, near the base of Sawdons Road, which latter locality is the most favorable one for their study. The upper part also is well seen at Saltwick Nab, of which it forms the base, and where good specimens of its characteristic fossils may be easily obtained. It continues thence right across Saltwick Bay to Black Nab on the other side. Between Sandsend and Kettleness there is a very good exposure of its beds; and here too its fossils may be collected, especially *Aptychus*. At the alum-works at Kettleness, descending to the high-water mark at Hob Hole, they occur halfway up the cliff: hence they skirt the south side of Runswick Bay, constituting a well-marked terrace in the cliff. On the north of Runswick they lie on the shore; and here some of their rarest fossils have been found. From this point onwards to Staithes, although they occur in the cliffs, and fragments are numerous on the shore, from which many characteristic fossils may be obtained, they do not present any particular opportunities for study.

Throughout the extensive liassic bay to the south and west of Staithes exposures of this rock are, with one exception, by the stream in Well Dale, below Hinderwell, confined to its western boundary. Jet-workings have been carried on in Park Wood; but on approaching Boulby House a terrace begins to assume prominence, which, on tracing it into the sea-cliffs, is found to be made by the jet-rock, which thence forms a well-marked band to the western

extremity of Lofthouse Alum-works, after which it is no longer seen at the surface excepting in inland stations.

It constitutes an outlier at Hob Hill, sections of which may be advantageously studied on the south side overlooking the gorge of the Skelton beck.

It is well exposed at West Upsall, and at Slape Wath, where it is ground and made up into bricks.

At Cod Hill, Hutton, where jet-mining still lingers, we come to the first of a range of old workings, which carry the line of this rock, feathering in and out among the depressions and protuberances of the surface, as far as the south-west front of Roseberry. On the south side of the Whin Dyke, by Bank House, the jet-workings recommence; and by their aid and the very marked terrace the rock makes on the slope of the high ground of Easby Moor, the range of the series is traceable as far as the ironstone-mine at Kildale.

All along the steep liassic escarpment, commencing at Battersby Crags as far as Scarth-Nick, near Swainby, the old jet-workings, visible from a great distance, permit of a very accurate survey of this series of rocks. The workings also extend around the Oolitic outlier of Whorlton Hill. The Scarth-Nick fault throws the jet-rock into the low ground, hence unfavourably situated for its exploitation; however, an opening has been made in Scarth Wood. In its southerly course it regains somewhat its position in the scarped front, beneath the Oolitic plateau, and has been worked at Lady's Chapel, near Osmotherley. On the south side of Cod Beck, at this place, jet-rock is seen beneath the old alum-works; and near to Over Silton it is seen for the last time in the northern area, excepting, however, its exposure on the north-western slope of the oolitic outlier of Borrowby.

To the west of Low Kilburn diggings have been made for jet, and the débris are still scattered on the surface; the beds, however, dipping rapidly to the east, soon carry the rock to an inconvenient depth.

At the Sessay cutting before mentioned, the last beds visible going upwards are the jet-rocks, bituminous shales of which occur with *A. elegans*.

In the southern area there is no zone so wanting of indications as this. On the top of the windmill-hill near Easingwold, between the road and Haverthwaites, occur hard thin shales with wood, which seem more nearly allied to jet-shales than to any others; and the position is suitable. The same may be said of Howe, in the same locality, By the side of the river Derwent, at the falls near Kirkham station, there is a quantity of bituminous shales undoubtedly belonging to this zone; and they are apparently *in situ*. They are not known to occur south of Market Weighton.

Inliers of Jet.—The jet-workings of the dales have been very numerous; but they seldom present any features of interest, and serve chiefly to determine the probable position of the less-exposed ironstone below. For this purpose it will be well to indicate localities

of these, which girdle round the various valleys. They are as follows:—

Basedale.—The jet-rocks are the lowest to which this secluded valley penetrates; and they may be seen in the stream at the entrance to the narrow gorge running south, and in an old working by the stream-side north of the Abbey.

Westerdale.—Above the Grange; above New House; on the hill south of Park House; by the path-side at the narrowest part of Esklets; very numerous exposures round Top End; up the eastern Head near Tucker House; between Dale Head and Hollins.

Danbydale.—No workings; only to be seen near the Head on the western side.

Fryup.—No workings; skirts the Round Hill, and is seen at the base of the slips along the eastern side near the Head of Great Fryup, at which place itself the whole succession may be seen.

Glaizedale.—In its proper place on both sides of the West Arncliffe shale gorge; at the base of the slips at the Head.

Eskdale.—In cliffs below Delves up Butter Becks; above the ironstone in Murk Esk, near Carr House; in the stream for some distance below Little Beck; in Iburndale.

Bilsdale.—The jet-rock in this dale and its confluent Raisdale has been and is the most extensively worked, the indications of which are so uninterrupted that it is superfluous to record them.

Bransdale.—For some distance along the stream up the eastern Head; in Heater Plantation; above Low South House; by Catharine House; in the stream a quarter of a mile below it, and several places on the east side of the valley between that and Barker Plantation.

Farndale.—Above Spring House; several pits above Spout House, Frost Hill, and Eller House; near Dick Wood; up Blakey Gill; over High Brag House; west side of West Gill; in the stream by Hollin Park, and northwards.

Rosedale.—West of Red House; near Hill Houses; near High House; on both sides of North Dale near Low Crags; above Thorgill; on Daleside road, below Lane Head.

JET AND JET-WORKING.

There is nothing perhaps with which Whitby is more generally connected than with jet; large quantities of ornaments are yearly made of this substance, that which comes from Whitby or, rather, from Yorkshire being considered the best. There are great differences, however, in its various qualities even here, as it varies greatly in hardness. Some samples are so soft that they will not admit of being carved, in which case they are of no use, and are called bastard jet; others will only admit of an inferior polish, while the best "hard" jet has an exceedingly brilliant lustre. These varieties lie in different beds, the best being found from halfway down to near the base of the jet-bearing strata. The getting of jet has been followed from very early times. The name, according to Pliny, is derived from a river and town in Lycia, called Gagas; hence the

term "gagates," which has been gradually shortened into jet. Whether or not this was the same substance that is found at Whitby is difficult to say; several black shining substances may have been confounded under the same name, as many properties are ascribed to it which are not known to belong to that from Whitby. As, however, no other jet is known to have been used in the British Isles, we are justified in concluding that all that is found in barrows &c., or alluded to by authors, is from Yorkshire. It is certain that jet was used in pre-Roman times, as ornaments made of it are found in barrows of Celtic age (Woodyate's Wilts, Hoare, Auct. Wilts, pl. 3, 4). It was also largely employed by the Romans themselves, several very beautiful examples having been found in stone coffins near York. There can be no doubt that, in connexion with Whitby Abbey, many crosses or rosaries would be formed of it. We think we can point to one place at least, inland, whence these early supplies were obtained, namely—on the side of Roseberry Topping; but it is probable that the greater amount would be picked up on the sea-shore, where in former days it would be plentiful, being washed out of the cliff. There is but little to find there now, it having been all picked up; but it has only of late years ceased to be worth while to walk along the shore to look for it. The use of it appears to have died out in the reign of Elizabeth, probably from this source failing; but in 1800, when more would have accumulated, the manufacture was recommenced. The present workers, however, are not dependent on this supply, but mine the jet-rock themselves, both in the cliff and inland. Jet-getting is very precarious and, on the cliff, dangerous. There is nothing to guide the miner to the locality of any piece of jet except being on the right level; its exploitation is therefore of a highly speculative character, and the profits of a successful season are very often absorbed in a fruitless search at another time. It is recorded that Mr. Charles Bryan had the good fortune to bring up the largest seam of jet ever discovered, from the North Bats, near Whitby, about the year 1847, which weighed 370 stone, and was worth about £250.

The usual mode of working is to drive headways 4 feet wide and 5 feet high, and intersecting boards at regular intervals. The mineral occurs in lenticular masses in the planes of bedding of the shale. The refuse shale from the cliff-workings is thrown out onto the shore; but inland it forms great heaps on the hill-side, very disfiguring to the country—so much so, that landowners in many instances will not allow any jet-getting; even otherwise the mining is only carried on above the limits of tillage.

The manufacture of jet ornaments gives employment to about 1500 persons; and the value of the trade in 1872 amounted to £88,000.

Jet in its mineral composition is very similar to anthracite. The beds in which it occurs are highly charged with bitumen, the fresh-broken shale smelling strongly of it. In seeking, therefore, for the origin of jet we can trace it immediately to this substance in the shales; its presence and the shaly nature of the rock are sufficient

to account for it. It is the result of the segregation of the bitumen in the intervals of the shales, which, allowing to a certain extent the access of air, has hardened it into jet, a process which may undoubtedly be now going on. So in cases where it is confined in a nodule it still remains unhardened. There seems to be no reason whatever for connecting it with wood, beyond its having a remotely similar composition—though, of course, we have thrown no light on the cause of the presence of the bitumen itself. Many fossils found in the jet-rock (wood, scales of *Lepidotus*, &c.) are themselves formed of jet; in this case, however it may be elsewhere unexampled, we must consider them pseudomorphs formed by the substitution of the bitumen for the decayed matter of the fossil, the fact of their consisting of, and not merely being covered by jet being certain. In the Kimmeridge Clay of the south of England we have an analogous phenomenon in the bituminous shales of that formation. In these, too, we meet with wood almost in the state of jet; and the chief difference appears to lie in the less complete segregation in this case. If we assume, as is most probable, that the bitumen is derived from the decayed vegetation of the period, it would appear that those circumstances that were most favourable to the deposition of finely laminated shales were also such as would allow the greatest accumulation, without dispersion, of these vegetable débris.

PALÆONTOLOGY.

The most interesting feature of the palæontology of the jet-rock is the occurrence in it of large numbers of fishes and reptiles. The most characteristic of these is *Lepidotus semiserratus*, which is very common and is commonly called the "scale-fish" from its ganoid scales. All the fish are peculiar, and belong chiefly to the genera *Pachycormus*, *Ptycholepis*, *Leptolepis*, and *Gyrosteus*. During the workings, too, for the jet several specimens of *Plesiosaurus* and *Ichthyosaurus* have been brought to light, though skeletons of these, as well as of *Gyrosteus*, occur also in the Alum-shale. The *Aptychi* are also a peculiar feature of the fossils of this series. They are here plentiful; but in no other member of the Yorkshire Lias do we know them to occur. Other forms, too, of Cephalopods are only developed here, namely those allied to the present *Loligo* or the *Sepia*. Of these there are four species. They are not, perhaps, a very interesting set of beds for the working palæontologist, as the fossils which are the most characteristic are chiefly such as are not likely to be met with in an ordinary exploration from which observation, however, we must except the Belemnites, which have a good specific development, and are moderately common. Although the fossils are few, they are almost all of them peculiar to this zone, which is thus very well marked palæontologically. *Inoceramus dubius*, the only conchifer at all abundant, has been found very rarely in the *annulatus*-shales below; and *Ammonites gracilis*, if not identical with *A. communis*, is very nearly allied to it; while *A. hetero-*

phyllus and *A. elegans* are undoubtedly common to this zone and the one above it. *A. aalensis* and *A. cornucopia* also occur out of the zone, as do *Belemnites breviformis*, *B. lævis*, and *B. Voltzii.*

Fossils of the Zone of Ammonites serpentinus.

Steneosaurus brevior.
Ichthyosaurus tenuirostris.
Plesiosaurus longirostris.
—— propinquus.
Gyrosteus mirabilis.
Æchmodus ovalis.
Lepidotus semiserratus.
—— rugosus.
—— pectinatus.
Pachycormus curtus.
—— latirostris.
—— gracilis.
—— latus.
—— macropterus.
—— acutirostris.
—— latipennis.
Ptycholepis bollensis.
Leptolepis saltviciensis.
Aspidorhynchus anglicus.
Belonostomus acutus.
Beloteuthis subcostatus.
—— Leckenbyi.
Geoteuthis coriaceus.
Teudopsis cuspidata.
Belemnites tubularis.
—— inæquistriatus.
—— dorsalis.
—— crossotelus.
—— Voltzii.
—— breviformis.
—— striolatus.
—— lævis.
—— acuminatus.
Belemnites scabrosus.
—— subtenuis.
—— subaduncatus.
—— tripartitus.
Ammonites heterophyllus.
—— Levisoni.
—— gracilis.
—— crassescens.
—— elegans.
—— aalensis.
—— serpentinus.
—— exaratus.
—— cæcilia.
—— subconcavus.
—— lineatus.
—— cornucopia.
—— erratus.
Natica buccinoides.
Discohelix minutus.
Inoceramus dubius.
—— Simpsoni.
Tancredia dubia.
Posidonomya Bronni.
Pecten pumilus.
Monotis substriatus.
Pleuromya bituminosa.
Ceromya exarata.
Modiola Simpsoni.
Protocardium substriatulum?
Discina reflexa.
Extracrinus briareus.
—— dichotomus.
Pachyphyllum peregrinum.

CHAPTER XVII.

ZONE OF AMMONITES COMMUNIS, OR ALUM-SHALE.

Except at Peak, where the Lias is most complete and beds belonging to the zone of *Ammonites jurensis* occur, the "Alum-shale" constitutes its uppermost portion, and is overlain immediately by the Inferior Oolite. It consists of hard blue shale, which readily breaks up into small fragments of little thickness, and when dry is remarkably crisp under foot. On exposure to the air it gradually becomes incrusted with sulphur, particularly at the edges. It has also a smooth unctuous feel. It is not so hard as the jet-shales, and splits into smaller fragments; and the two are easily distinguished by their appearance, if not by their smell. The shales of the *annulatus*-beds are more similar to it; but they are more sandy in appearance, and do not split into such fine layers. It is by no means, however, so easy to distinguish the alum-shale from some that occur near the base of the Inferior Oolite; and many mistakes have been made in consequence. Fossils, when present, will of course distinguish them, though both shales are rather barren of these, except in particular parts; but in their absence it is sometimes almost impossible to decide which we have before us. The oolitic shales are, as a rule, softer, more easily split along the layers, and more sulphurous and sandy.

There is no lack of exposures of this zone, worked as it has been so long a time for the manufacture of alum, occurring so continuously along the sea-shore, and supporting in so many valleys and escarpments the oolitic rocks, which form the tops of their precipitous sides. The fossils of this zone lie generally in definite lines, while others are spread through definite thicknesses; but with the exception of bands of dogger-stone, which are not very numerous, it consists of a uniform mass of these shales, and yet, in spite of its many exposures, can only be satisfactorily examined on the sea-shore.

The upper portion of it contains lines of nodules that are used for the manufacture of hydraulic cement (the far-famed Mulgrave cement), although with the alum-industry itself the selling of them has almost ceased. Below this is the main supply of alum-shale, said to be coextensive with the range of a particular fossil (*Leda ovum*); and we reckon the zone to descend below this some 36 feet through shales which are unproductive of alum.

In the neighbourhood of Whitby, commencing near the east pier, we get the following section:—

No.	Lithology.	Thickness.	Fossils.
	Oolitic ironstone at the base of the Inferior Oolite.	ft. in.	
1.	Lias shale	6 6	*Ammonites elegans*, *Belemnites subaduncatus*.
2.	Line of cement-nodules with cone-in-cone structure.	0 4	*Am. bifrons*, *Plesiosaurus*.
3.	Shale	1 8	*Am. crassus*.
4.	Line of cement-stones	0 4	
5.	Blue shale	1 10	
6.	Cement-stones	0 5	
7.	Blue shale	2 10	*Am. bifrons*.
8.	Cement-stone......................	0 5	
9.	Blue shale, with scattered irregular doggers.	35 0	
10.	Strong well-marked dogger (just misses the top of Saltwick Nab).	0 6	to 12 in.
11.	Blue shale	16 8	*Am. bifrons* (at the top), *Am. communis* (in the centre).
12.	Indurated band of shale	0 4	*Lingula longoviciensis*, *Eryon Hartmanni*, *Monotis substriatus*.
13.	Shale	18 0	*Am. elegans*.
14.	Dogger band	0 6	
15.	Shale	17 0	*Am. primordialis*, *Monotis substriatus*.
16.	Distinct line of doggers (runs round Saltwick Nab).	0 4	
	Blue shale	10 0	
	Base of zone of *Am. communis*.		
	Blue shale		*Inoceramus dubius*.

This gives a thickness to the beds of this zone of about 107 feet; but as the beds cannot all be measured in one spot, and only from dogger to dogger, and the interval between these is found to vary as we pass along, the total measurement can be only considered approximate: it is probably rather more than this. The first eight beds are occupied by the cement-stones, descending through a thickness of 15 feet; but these are the most varying of all. Then comes that portion which is the chief source of alum, down to the bottom of bed 11, including altogether a depth of 67 feet. The beds below this are said not to be so productive; and the *Leda ovum* does not occur in them. One feature of these shales is worth mentioning—namely, the occurrence of the Ammonites in different states of preservation according as they lie in particular lines. They are scattered all through the beds; but when they come from these lines, and then only, is there any chance of their making good sections. These lines are known to the collectors, and are called by various names, "Ammonite," "double back," "green back," according to

the various species they contain. It is to these, no doubt, that Drayton alludes when he writes of Whitby:—

> "And stones like serpents there, yet may yee more behold
> That, in their naturall gyves, are up together rold."

And they were doubtless far more numerous in his time than now, after so many thousands have been carried away by collectors. It seems probable that the same cause which has acted to prevent all being equally well preserved, may have completely prevented the preservation of some more delicate forms; and the fauna may have been richer than it now appears—unless we are to suppose from the well-preserved Ammonites being all in one identical line of deposit, that they were overwhelmed while in full vigour, and thus that their state at the time of their interment has caused their preservation.

Exposures of the Alum-shale.

1. *On the Escarpment.*

The alum-shale is first seen on the shore between Blea Wyke and the Peak; and its base is about 20 feet up the cliff, on the south side of the fault. After passing the fault it is exposed in the old alum-works of Peak and Brow, and forms either side of the gorge of Howdale, spreading here over the whole side of the hill. It is seen again low down in a tributary of Mill Beck, near Pretty House. When it has once more risen in the hill over Thorpe, it again forms a well-marked feature by the road-side above Park-gate; after this it is seen no more in Robin Hood's Bay, being covered with oolitic débris. On rounding the north corner of the bay, the hill-side beneath Bay Ness is strewed with its fragments brought out by rabbits from their holes. North of this we must look for it on the cliff-side; and but for the roughness of the way it might be followed all along from Hawsker Bottoms (Sawdon's Road) to Whitby. Beyond the Whitby fault it does not appear again till we see it occasionally uncovered by the overlapping Boulder-clay near East Row, Sandsend. On tracing up the parallel becks, however, we find the whole sides of these gorges covered with these beds. This, in fact, is a very common feature of narrow deep gorges, where the capping of Oolite is but thin. The water having once made its way through this, the shale below affords but little resistance, and the gorge is quickly made deeper, leaving precipitous shaly sides, with often a waterfall above and a slow-running stream below, the water wearing its bed away until the slightness of its incline leaves it no excavating power. We might have made these observations with respect to Howdale Beck, as they are applicable to so many instances. We will call such a feature a "shale-gorge." From Sandsend, the alum-shale may be followed all along the cliff to Kettleness, when the tide allows. Here it is near the top of the cliff, where it was formerly worked. It is also shown on the other side of the bay, in the cliff-sides, but faulted to different levels. It forms the shale-

gorge of the Rousby and Easington Becks, west of which it occupies the high ground by the sea-side, having been here worked in the Boulby and Lofthouse alum-works.

The opportunities for study of the alum-shale in the north-western part of Cleveland are few and far between. After leaving the coast, the first to be enconntered is the site of the old alum-works of Skelton, in the valley through which Saltburn Beck has its course. It is well seen on the front of Eston Nab, again at Slape Wath, and Spa-Wood old alum-works, at Cass-Rock Quarry, near Guisborough. Then there are many exposures between Hutton and Roseberry, a few limited sections in Sleddale and Lonsdale, but a more extensive one at the old alum-works, Little-Ayton Moor. Along the hill-range from Kildale to Osmotherley bared surfaces showing alum-shale are frequent; but the most complete section in this district is that of the old alum-shale quarry of Carlton Bank, which has yielded several of the common species of this horizon. The southern limit of the alum-shale industry appears to have been at Osmotherley, where in the old quarry by Cod Beck the reduced thickness of the shale may be well proved. It intervenes between the jet-rock and oolitic ironstone on the Borrowby outlier.

South of Over Silton very few exposures are known, the Oolites having now sunk nearly to the general level of the country; the escarpment is a lower one, and is not supported by visible beds of alum-shale. It is only seen in the junction before mentioned, near Feliskirk. It has been stated by Marley to occur in Storth Wood, near Weston Hall; but on examination it is clear that the shales there seen are oolitic; they do not contain liassic fossils, they can be lithologically distinguished, and they have beds of sandstone *below* them. We know of the presence of alum-shale, and of its attenuation, at Mount St. John by the published section of the boring made there, the whole Upper Lias being 110 feet, and therefore the alum-shale not much more than 50; but it is not exposed on the surface. Overlying the jet-rock at Kilburn these shales appear with *A. bifrons*; and the zone is exposed again in the railway-cutting of the Malton and Thirsk line, at its crossing of the Thirsk-and-Easingwold Road; and near this the oolitic top of the hill above Husthwaite, sloping towards Coxwold, is supported by these shales, making broken ground on the hill-side, appearing in the road-side sections leading down to the middle of the village, and met with to the depth of 40 feet in a well-sinking on the top of the hill. This is the last that is definitely seen of this zone for many miles, in fact nearly the end of its consecutive range: all the liassic exposures in the boulder-covered country running to the east are of lower zones. When we arrive at the Derwent valley, in the neighbourhood of Kirkham, the alum-shales are exposed in the wood at the side of the road leading up the hill; and their position in this locality may be well understood by the section of the boring made at Mount Pleasant, given by Dr. Wright*, where they were met with after passing through 83 feet of oolite rock and shales.

* Quart. Journ. Geol. Soc. vol. xvi. 1860, p. 33.

The section, of which the following is a copy, is very interesting as compared with those of Eskdale and Fryup:—

			ft.	in.
		Inferior Ooolite beds	34	2
Inferior Oolite	1.	Red sandstone	9	0
	2.	Freestone dogger	2	0
	3.	Hard black shale	13	0
	4.	Clay Ironstone	3	4
	5.	Dry blue shale	8	0
	6.	Fossiliferous Ironstone (fossils like those of Glaizedale)	5	0
	7.	Hard callous shale	2	8
	8.	Ironstone	1	0
	9.	Yellow dry shale	4	6
Upper Lias	10.	Blue dry shale	4	0
	11.	Black dry shale	0	6
	12.	Blue dry shale	6	0
	13.	Black hard shale	0	6
	14.	Alum-shale	2	6
	15.	Hard dry shale	6	0
	16.	Dry sandy shale	2	0
	17.	Black clay	3	0
	18.	Light-coloured clay	2	6

The succession of 1, 2, 3 may be followed on the hill-side above the railway (not mistaking No. 3 for Lias), No. 6 to No. 9 in the railway-cutting beyond Castle-Howard station, and the various succeeding shales on the south of the road leading up from Kirkham towards Whitwell. Nos. 10–13 are called by Dr. Wright "Basement or *striatulus*-bed," but without fossil evidence. But we see that here, as in the north, the change into alum-shale below the ironstone is gradual, and the line of junction must be drawn in the midst of shales.

The zone is seen no more till we reach nearly the extreme end of the southern area and the whole Liassic strike has changed. Here, to the south of Market Weighton, it is again well developed, and emerges from beneath the Chalk just south of the Beverley road; it is proved by pond-diggings at various places beneath the Oolite. In its southern course, and between Sancton and Haughton Hall, immense numbers of *Am. communis* and *A. bifrons* have been taken out of it, with which the roads have been mended.

2. *Inliers of Alum-shale.*

With respect to these, when we have described one valley we have described all. In every one this zone skirts the sides beneath the Oolite, and is constantly exposed: the only caution necessary is that we do not confound it with oolitic shales above; and this is the more difficult as neither are very fossiliferous. The oolitic shales, however, are not of great thickness, and nodules with characteristic fossils underlie them, so that some 20 or 30 feet of shale is pretty conclusive of its being alum-shale. An exception to this, however, must be made for Rosedale, at the magnetic-iron mines. These occur in large boat-shaped masses in shales, said to reach even 100 feet, which might well be mistaken for alum-

shale; they are, however, destitute of fossils, and true alum-shale with fossils occurs below; and thus the shales as well as the contained ironstone are exceptional.

The following are the chief exposures of interest in the dales:—

Basedale.—The Oolite has mostly slipped over and covered it here; but sections are seen to the east at Hograh Field and all along the river-gorge to the south.

Westerdale.—Below Birk-field quarry (faulted); Spring Dike; Stock-Dale Head (south side); thence all round Esklets; Waites House; Top End; Otter Hill.

Danbydale.—Over Boggle House; below Danby Low Moor; near Eller Wood; beneath High and Low Crags; Danby Head; near Lumley House.

Fryup.—East of Danby Castle; Danby Lawns; Stanch Bullen; Jackdaw Crags; all round Fryup Head; in a shale-gorge, eastern end of Crankley Gill. It will be noticed in these three dales that the alum-shale is clearer of the oolitic débris on the western than on the eastern side; this is no doubt due to the dip of the strata.

Glaizedale.—In the river beside the iron-works; in Limber Hill Bank; in shale-gorges in West and East Arncliffe Woods; in Hard-hill Gill; at Glaizedale Head.

Eskdale.—The alum-shale continues from the last valley through the gorge at Arncliffe, past Egton Bridge, and may be seen in Limber-Hill Wood; up Butter Beck; crossed by the Whinstone Dyke in Duckscar Quarry; at Scalby Hill; in Blue Beck; top of Brow Wood; below Lease-Rigg Quarry; along the gorge of the Murk Esk as far as the base of Keld Scar, two and a quarter miles from Grosmont; along the south of Eskdaleside at Grosmont, by the old and new alum-works, to Blue Bank, Sleights; in a gorge below Aislaby.

Iburndale.—At Goathland-Banks alum-works; up Wash Beck; at Little-Beck alum-works; all along the gorge beneath Newton House, and beneath the beautiful waterfall of Falling Force.

Bilsdale.—The chief exposures of the alum-shale are along the courses of the moor-burns, and are mainly limited to its upper portion, such as at West Park, Tripsdale Beck, and Hole Beck, on the eastern side of the dale; Fangdale Beck, and along the steep escarpment into Raisdale. On the north-western side the exposures are limited to the neighbourhood of Northwood and Broadfields.

Alum-shale is exposed in the south bank of Raisdale Beck, between the Mill and Staindale, and is seen at the surface on the north-west side of Wath Hill, and along the steep escarpment bounding the dale on its south side.

Bransdale.—Along both the eastern and western Heads; in the midst of High Plantation; over Bransdale Castle and Cowl House; and Elm House; on the road to Farndale; round Barker Plantation, and in a deep narrow gorge through which the water escapes at the south, and in a branch of the same.

Farndale.—All round the western Head; under Gill Wath; east side of Old-Beck Head; continuously along the west side from Spring House to Monket-House Crags; west side of Potters Nab;

on the road to Little Blakey; above High-Brag House; continuously round Horn Nab; up West-Gill gorge; above Scarth Nick; above Cross; below Taylor Nab; in the stream at the south.

Rosedale.—All round the western Head; above Hollin Bush; in two gorges on the opposite side; above High House and Craven-Garth House; below Bell Common; up the gorges of the eastern Head; at Low Crags; at the Otter Hills; over Hob Farm and Red House; round Abbey Head; up the road to Heygate; on the road up to the magnetic-ironstone mines; on the highroad between Pry Hills and Mill Farm; in the stream-side near, and also beyond Spires House.

There is no Lias in Hartoft Dale, or Bonfield Gill, as marked by Bewick, the shales interstratified with the sandstones of the Oolite having evidently been mistaken for Upper Lias.

Alum-manufacture.

The interest of the alum-manufacture as connected with Whitby has nearly passed away. Wherever we go we find abandoned works, some of great magnitude, as the Peak, Brow, Kettleness, Boulby, Lofthouse, and Iburndale alum-works. The last remaining sign of this once important industry is at Sandsend; and there they are only working-off old stores, and have run the new railway through the calcining-ground. The reason is that the monopoly no longer exists. Formerly the shale of Whitby was the only natural source of alum; and therefore, though it laboured under the disadvantages of inaccessibility and distance of fuel, the trade flourished; but a new process invented about 25 years ago by Mr. Spence, of Manchester, resulted in the extraction of a better percentage from coal-shale; and, further, by utilizing in the process the ammoniacal liquor of the gas-works, alum could be manufactured cheaper on the spot where it was wanted than at Whitby; and thus the Yorkshire product was driven out of the field. It may be interesting, however, to give a passing account of the history and nature of the alum-making as connected with Whitby, but not so fully as if the manufacture were still carried on.

There are various kinds of alum known to the chemist; but the only two of any commercial importance are the potash-alum and the ammonia-alum. They consist essentially of an aluminium sulphate united with an alkaline sulphate either of potash or ammonia with water in combination.

The aluminium sulphate is obtained from the rock in a state not fit for use, and has to be mixed with the alkaline sulphate. The kind that was formerly made at Whitby was always potash-alum, this alkali being added in the form either of potassium sulphate or potassium chloride. The shale had first to be calcined. This was done by spreading brushwood over a large area, and covering it with about 4 feet of shale, when the wood was set fire to; and as the mass became heated more shale was added till it had reached a considerable height; care was required that the temperature should

not rise too high, lest the sulphur should escape. This part, therefore, of the process occupied from one to two years. The calcining-places may be seen in any of the old alum-works.

The next part of the process was to wash the burnt shale to obtain the soluble matter, consisting chiefly of the aluminium sulphate. This was done in large cisterns, several of which followed one another on descending levels. In the highest was placed the calcined shale, where it was washed, the liquors passing into the other cisterns, and finally to the boiling-house, while the shale was afterwards thrown on one side in heaps, immense remains of which are seen in all these old works. The liquor was then evaporated in the boiling-house, the potash-salt added, which precipitated the alum in the form of flour; and it was afterwards dissolved in boiling water, and poured into "roaching" casks to crystallize. Such is a brief outline of the process as far as it illustrates the use of the works we see remaining. The new process, which has superseded it, is somewhat similar, only that to the calcined shale sulphuric acid has to be added in excess. This is easily obtained from the pyrites which is common in the carboniferous series; and instead of a potash-salt ammoniacal liquor from the gas-works is used, the vapour from which unites with the excess of sulphuric acid, forming ammonium sulphate, which again unites with the aluminium sulphate, and forms alum. Since, then, it appears that the aluminium sulphate can be obtained with equal ease from other shales as from those of Whitby, and the other ingredients are more easily procured elsewhere, there is very little chance of the alum-manufacture returning to Whitby, unless the product is for use on the spot.

An analysis of the alum-shale of Whitby, given by Messrs. Richardson and Ronalds (see Ure's Dict. of Arts), gives:—

	Top.	Bottom.
Iron sulphide	4·20	8·50
Silica	52·25	51·16
Iron protoxide	8.49	6·11
Alumina	18·75	18·30
Lime	1·25	2·15
Magnesia	·91	·90
Sulphuric acid	1·37	2·50
Potash	0·13	tr.
Soda	0·20	tr.
Coal	4·07	8·29
Water	2·88	2·00
	95·40	99·91

Palæontology.

The chief interest which attaches to the organic remains of this zone is connected with the Reptilia. It is even more rich than the jet-rock in these relics, most of the larger specimens coming from this horizon, and this being the home of the *Teleosaurus Chapmanni.* In the south of England the reptiles are found at the base of the Lias, and we have no reason, when we remember the uniform,

though scarce, occurrence of their remains in our lower zones to believe them absent from our seas at the period of their deposition; but it was during the more recent portion of the Liassic period that the conditions of their life and preservation became favourable here as in the Ilminster district. They are abundant both in species and numbers, and were the giants of the race. The profusion too of Cephalopods here reaches its height; Belemnites and Ammonites may be procured by the hundred, though the distinct forms are not numerous, the various so-called species being very closely allied. The fossils peculiar to the zone are the Reptiles, the Nautili, *Belemnites levidensis* and *pollex*, all the Ammonites except *A. heterophyllus*, *A. Levisoni*, and *A. elegans*, and all the other fossils except *Trigonia literata*, *Ostrea subauricularis*, and *Gresslya donaciformis* (which pass into the *jurensis*-beds), *Pecten pumilus* and *Monotis inæquivalvis* (which come up from below and pass on), and *Monotis substriatus* and *Discina reflexa* (which are continued into the Inferior Oolite).

List of Fossils of the Alum Shale.

Teleosaurus Chapmanni.
Ichthyosaurus crassimanus.
—— acutirostris.
—— longirostris.
Plesiosaurus homalospondylus.
—— Cramptoni.
—— Zetlandi.
Gyrosteus mirabilis.
Nautilus astacoides.
—— jurensis.
Belemnites vulgaris.
—— lævis.
—— levidensis.
—— Voltzii.
Ammonites communis.
—— Holandrei.
—— crassus.
—— Braunianus.
—— heterophyllus.
—— subcarinatus.
—— Desplacei.
—— bifrons.
—— Levisoni.
Ammonites subarmatus.
—— lythensis.
—— elegans.
—— fibulatus.
—— fonticulus.
—— primordialis.
Cerithium quadrilineatum.
Leda ovum.
Trigonia literata.
Gresslya donaciformis.
—— rotundata.
Arcomya elegans.
Monotis substriata.
—— inæquivalvis.
Pecten pumilus.
Hinnites papyraceus.
Ostrea subauricularis.
Thracia glabra.
Inoceramus cinctus.
Discina reflexa.
Lingula longoviciensis.
Eryon Hartmanni.

CHAPTER XVIII.

ZONE OF AMMONITES JURENSIS.

In treating of the junction between the Upper Lias and Inferior Oolite, we have already stated that we consider that the only locality where beds of this age may be seen is at the Peak, and that we exclude from it all the beds known as the Blea-Wyke beds. Very possibly some of the uppermost portions of the shales in other localities ought to be included in this zone, as Dr. Wright has done with regard to the Mount-Pleasant boring; but until fossil-evidence is forthcoming we cannot see any advantage in it. As thus restricted, the zone of *A. jurensis* consists only of four beds of sandy micaceous shale, each about 20 feet thick, separated by irregular nodular bands, which are the usual repositories of the fossils. They may be reached beneath the cliff at Peak; but on the shore they are completely covered by débris from the Oolite covering. This very restricted range gives little opportunity for studying them; but they have been found to contain the following suite of fossils. Of these we have seen that some undoubtedly pass up into the Oolites, as *Discina reflexa* and *Monotis substriatus*, *Pecten disciformis*, *Venus tenuis*, *Dentalium elongatum*, *Gresslya abducta*, and possibly (*fide* Young and Bird) *Ammonites striatulus*; but the first two occur in the alum-shale, and the rest are either peculiar or Upper-Lias forms; so that we are justified in including these beds in that division. They have, however, essentially the character that is usually assigned to "passage-beds;" that is, the peculiar forms are in a minority, consisting chiefly of the Ammonites, which, on the other hand, are not so restricted in other localities. The remainder of the fauna is chiefly composed of the last remnants of Liassic life mixed with the first dawning of Oolitic.

List of Fossils of the Zone of A. jurensis.

Ichthyosaurus, sp.	Ammonites comensis.
Ammonites striatulus.	Belemnites athleticus.
—— jurensis.	Dentalium elongatum.
—— variabilis.	Actæonina pulla.
—— compactilis.	Cerithium armatum.
—— serridens.	Venus tenuis.
—— Germanii.	Gresslya donaciformis.
—— insignis.	Protocardium substriatulum.
—— fabulis.	Leda æquilatera.

Trigonia literata.
Pecten disciformis.
—— pumilus.
Lima toarcensis.
Monotis inæquivalvis.
Monotis substriata.
Ostrea subauricularis.
Discina reflexa.
Waldheimia Lycetti.
Rhynchonella jurensis.

CHAPTER XIX.

STRATIGRAPHICAL PHENOMENA.

Thickness of Strata.—Various estimates have been given of the thickness of the Liassic rocks in North Yorkshire; but as they materially differ from one another, even where the same section has been measured by two observers, it is incumbent upon us to submit our independent calculations, without endeavouring to reconcile the discrepancies alluded to. Still it may be said, in explanation of the very great difference between our estimate and that of Phillips, which makes the nearest approach, that we have had fuller data at our command for such computation.

Young and Bird* measured the strata in the lofty cliffs at Boulby, the Liassic portions of which are given as follows:—

	ft.		ft.
Main bed of alum-rock	200	Upper Lias	210
Limestone nodules with alum-shales	10		
Hard alum-shale	30	Middle Lias	245
Ironstone series	15		
Shale with ironstone nodules	40		
Sandstone and limestones	60		
Alum-shale (not including slope of beach	100	Total	455

The lowest bed is estimated at 130 feet in Huntcliff; and to the above total they would add 50 fathoms of aluminous strata, ascertained by boring at Coatham, and which are rightly considered by them to belong to a lower portion of the Lias than the foot of Huntcliff†.

These additions give a total of 785 feet, from which, however, we would deduct 30 feet as belonging to the Inferior Oolite, leaving 755 feet of Liassic strata.

Hunton‡ made the Lias of the same section to be 80 feet thicker, or 510 feet in all, with which we agree, distributed as follows:—Upper Shale 200 feet, Marlstone 160 feet, and Lower Shale 150 feet; total 510 feet.

Phillips§ measured the five sections exposed on the coast between Whitby and Peak, which carry us down to a considerably lower

* Survey of the Yorkshire Coast, p. 134, 1828.
† *Loc. cit.* p. 147.
‡ Trans. Geol. Soc. vol. v. part 1, 2nd series, p. 215.
§ Geology of the Yorkshire Coast, p. 5, 1829.

horizon than the base of Boulby Cliffs. According to him the thickness is as follows:—Alum-shale 200 feet, marlstone 150 feet, Lower-Lias shale 500 feet; total 850 feet.

WILLIAMSON* estimates the alum-shale at 180 feet, the marlstone (between Staithes and Saltburn) at 130 feet, and the Lower Lias (at Peak Hill) at 300 feet, making a total of 610 feet, or 240 feet less than Phillips's measure.

SIMPSON† has given the following estimate of the same sections:—

	ft.	in.
Upper Lias—Alum-shale (south of Whitby)	188	0
Middle Lias—Ironstone-series (Hawsker) 79 ft. 3 in. } ,, Staithes beds ,, 58 ,, 8 ,, }	137	11
Lower Lias—Robin Hood's Bay (being our Middle Lias to base of *A.-armatus* zone)	151	11
Indurated bands of Lower Lias..........................	103	0
	580	10

from which he deduces a probable total of 600 feet.

North-west of Cleveland.—The base of the Lias was reached in the Eston gypsum-pit; and were the strata continuously horizontal, then the difference in altitude between the base of the Lias in the pit and its upper surface exposed on Eston Nab would alone represent a thickness of 870 feet; but the strata in the hill have a dip of 1 in 15 to the south-east, and the gypsum beds in the pit have a northerly rise, as proved by their position in the Middlesborough salt-pit, in the Lackenby gypsum-pit, and in the cliff-section at Lazenby (see p. 34). A horizontal section through the Eston gypsum-pit to Eston Moor, drawn to a true scale and with the ascertained dip, shows a total thickness of 1325 feet of Liassic strata (see plate of sections). Of this total there are certainly known Upper Lias 181, grey shales 33, Ironstone and other Middle-Lias strata 93½ feet in the hill-side, and 164 feet of Rhætic and Lower Lias in the pit; but there is therefore a very large proportion concealed. The section at Huntcliff partially fills the void by representing a depth of 323 feet of Middle Lias beneath the grey shales.

A section from Lazenby Cliff, through a well on West-Coatham Marsh, and a bore-hole to the south of Slake's pit to the outcrop of the *angulatus*-beds at Redcar, prove that 150 feet of Lias and Rhætic occur below the upper part of the *angulatus*-beds at Redcar—a determination which corroborates our opinion that the Eston sinking is solely in the *angulatus*-beds and inferior strata.

Above the *angulatus*-beds at Redcar there is an extensive spread of the *Bucklandi*-limestones and shales, affording a continuous section calculated to have a thickness of 200 feet. Between these and the *Jamesoni*-beds, on Coatham Scars (on the horizon of the base of Huntcliff), the sea intervenes with islets of the *oxynotus*- and *ar*-

* Trans. Geol. Soc. vol. v. part. 1, 2nd series, p. 223.
† 'Geology of Yorkshire Coast,' p. 47, 1868.

matus-series, the thickness of which is estimated at 340 feet. A section from the gas-works, Redcar, commencing at the level of the thick limestone towards the base of the *Bucklandi*-series, to the Off Heights on Coatham Scars, gives a thickness of 822 feet as belonging to the Lias intervening between the lower portion of the *Bucklandi*-beds and the upper portion of the *margaritatus*-sandstones. From these two independent series of measures the thickness of the Lias may be summarized as follows:—

I.	ft.
Upper Lias, Eston Nab	181
Grey shales „	33
„ Huntcliff	323
Jamesoni-beds, part of Coatham	40
Armatus- and *oxynotus*-beds, Redcar Bay	360
Bucklandi-beds, Redcar	180
Angulatus and *Rhætic*, Eston gypsum-pit	164
	1281

II.	ft.
Upper Lias, Eston	181
Grey shales „	33
Ironstone and subordinate shales	74
Margaritatus-sandstone to thick *Bucklandi*-limestone, Redcar to Coatham	822
Inferior part of *Bucklandi*, Redcar	10
Angulatus and *Rhætic*, Eston	164
	1284

The differences between these estimates and the calculated thickness in the Eston Hills are slight. The total thickness is probably everywhere else less than that at Eston; but in general it can only be estimated, and there is no other place along the western escarpment where it can be satisfactorily calculated, on account of either the existence of faults, or the probable remoteness of the nearest observed Keuper from the true line of junction.

In Robin Hood's Bay and Hawsker we obtain accurate measures as far as the *Bucklandi*-series, which we may consider as about one third exposed. If we add the Redcar measures for rocks below these, we obtain Rhætic 14 feet, Lower Lias 378 feet, Middle Lias 470 feet, Upper Lias 200 feet, to which we must add 80 feet for the zone of *A. jurensis*, making a total of 1142 feet.

These thicknesses greatly exceed those of Phillips (850 feet), Simpson (600 feet), and Bewick (700 feet); but the difference lies in each case in the beds below the *margaritatus*-zone, the Lower Lias of those authors: the last two have underestimated the *Jamesoni*- and *oxynotus*-zones; and the first has taken no account of the thickness of the Redcar rocks, which would make just the difference between the estimates.

A calculation of thickness between Feliskirk and Thirsk, on a supposition of a dip of $2\frac{1}{2}°$ in the direction measured between known exposures of Oolite and Keuper, give a total of 900 feet, which is probably above the truth, as the Upper Lias, as shown by Phillips, has here diminished to 116 feet.

These are the only complete estimates we can give in the northern area. In the south, where the series is complete, it is much diminished in thickness; a calculation across the strike south of Sancton, allowing a general dip of $2\frac{1}{2}°$, gives 600 feet as a maximum, the greater portion of which belongs probably to the Lower Lias.

Dip and Undulations.—The Liassic strata in Cleveland have a general dip south-east at a low angle; and in many extensive sections the true dip does not exceed 1 in 18, or about 3°. They are thrown into gentle undulations with an invariably greater dip on the north side than on the south side of the anticlinals. This phenomenon is well exemplified by the Redcar anticlinal, the northern dip increasing from 5° to 11°, whilst on the south the maximum is not 3½°—and by the Eston synclinal, the strata which dip down to the synclinal axis having a high dip, as may be well seen in the Ormsby mines, whilst the rise dip to the north in the Eston mines is only 1 in 14·5—and also by the Keuper marls at Seaton, near Hartlepool, as noted by Young and Bird, pp. 170, 171.

This dip becomes changed, south of the Guisborough Hills, by the influence of the master anticlinal that stretches in an easterly direction by Burton Head, Ingleby Greenhow, Blakey Topping, &c., along which the liassic rocks attain their greatest elevation above the sea-level, and which forms the watershed between the Humber and the Tees. Parallel to this, on the north and south, are synclinal axes—the northern one allowing the liassic rocks to appear on the coast, and the southern, more remote, forming the basin of the Vale of Pickering—one drained by the Esk, the other by the Derwent. Along the western escarpment the Lias has also a slight dip to the east; and in the south this is lost, and the beds have a north-westerly dip, as may be seen by the lower beds coming on as we pass from Oulston to Crambe. They would thus form half a basin, were it not for the above-mentioned anticlinal. This is also crossed by another at right angles to it, and of less consequence, as it scarcely affects the northern synclinal, and has its axis in Danby Ridge. The bases of the dales thus form a "saddle." These dales form a very interesting feature in the geology of Yorkshire. They are true liassic inliers of the general form of an elongated ellipse, with the axis nearly N.N.E. in the northern, and N.N.W. in the southern. They have picturesque precipitous sides formed by the massive Oolites which cap the Lias. None of them are connected by liassic surface rocks except Glaizedale and Eskdale. The streams that drain them have, of course, a greater fall than the dip of the rocks from the anticlinal at the head of the dales; but both in the southern and northern series the fall becomes afterwards less than the dip, and they flow over the edges of higher rocks. The initial origin of these valleys seems to be referable to lines of fracture produced by the elevating force along the anticlinal axis. This action does not seem to have produced transverse dislocations, though some faults parallel to the anticlinal are known; but no faults in the lengths of the valleys have been detected, excepting in the escarpment at Ingleby Greenhow and Battersby Moor, which probably formed part of the boundary to a dale forming one of the northern series; Scugdale is a remnant of another one, but belonging to the southern set. The denudation has taken place along the lines of fracture. The heads of many of the dales are but lines of fracture still, notably that of Basedale, as also of Bransdale and Bilsdale East; further

down their course the general denudation has widened them; but in some cases, as they encounter the Oolite again, they are narrowed into gorges, as in Glaizedale, East Arncliffe, Basedale, Bransdale, and Rosedale.

With regard to the epoch of their excavation, we must remark that the Boulder-clay scarcely reaches higher than 350 feet in the North Riding, and thus that these dales, which do not descend so low, are free from it. At the bases of them, however, are great mounds of sandy clay, with various-sized rather waterworn stones of local origin, as at Ainthorp, Fryup End, and Glaisdale End, which from their unstratified appearance seem best accounted for by glacial action; and as we descend lower in the same Esk valley, the blocks become large, and we reach, near Grosmont, true Boulder-clay with foreign blocks. It would seem, then, that these valleys were excavated before the glacial epoch, but that they were scoured out during it by ice, which left its accumulations in mounds at the ends.

Besides the large folds already described, there are several minor ones, which account for the geological features of the surface. An anticlinal is observable on the shore between Marske and Redcar, another which transversely intersects the long ridges of Pinchinthorpe Hill; also an extensive one courses from Rockcliff south-east into Eskdale, which is obviously succeeded by minor undulations on the north-east, as exhibited between Staithes and Kettleness. Robin Hood's Bay is elevated in the form of a mound, dipping in all directions from the centre, having synclinals exhibited in Iburndale and on the coast towards Whitby. Synclinals are observable traversing Ormsby and Eston Hills, at Ainthorpe, between Danby and Fryup, and at Leatholm Bridge, separating the liassic areas of Fryup and Glaizedale.

At Sleights Bridge phenomena are exhibited which may be due either to a sudden dip forming a synclinal, or to a fault, the critical localities for deciding the question being deeply covered with unstratified local Boulder-clay. The upper edge of the Lias rises from 375 feet at Little Beck, to 475 feet at Blue Bank, over Sleights, and is also rising towards the west, making the true dip about E.S.E. This involves an anticlinal along Eskdale, as the beds on the north side of the valley are at a slightly lower level; at Ugglebarnby the Oolite is dipping south-east, as it should; but at Sleights Bridge the *margaritatus*-beds are dipping rapidly north-east; half a mile east of this the Oolite-and-Lias junction is seen at a level of 50 feet. These phenomena may perhaps be accounted for by conceiving Eskdale as a centre of elevation from which the strata dip on all sides, rapidly on the north-east. They may, however, be cut off by a fault on that side coursing just west of Ugglebarnby, and east of Sleights Bridge.

Local flexures have been observed in the *margaritatus*-beds on the banks of Skelton Beck, where in one section the strata are perpendicular; on the west side of Sleddale Beck, near Sleddale Bridge, two miles east of Kildale, the alum-shale rises up into

the form of an arch. Contorted stratification in the Upper Lias is mentioned by Phillips as being visible in Runswick Bay; but this appearance and the Hob-Hole caves, depicted by Young and Bird, have since been masked or demolished.

Along the northern coast, the valleys generally are excavated in a direction contrary to the dip of the strata, but they do not appear to be connected with lines of dislocation. The Esk breaks through the escarpment on the line of a fault, which, however, is for a few yards only coincident with the direction of the valley; so also with regard to the Staithes beck. The narrow valleys through which the Saltburn and Skelton becks reach the sea slope to the north, whilst the strata over which they flow dip to the south-east; both have their source in the bay-like tract occupied by Upper Lias, between Boosbeck and Slapewath, which seems from the peaty accumulation on the surface to have been once a lake, and undoubtedly drained by these two streams flowing in opposite directions.

Passing now to the southern area, the chief feature is the important but gradual anticlinal, which raises the lower beds as we pass eastward to the Derwent from Brandsby, and which, being of pre-oolitic age, causes the Rhætic and Oolite to come into contact at Howsham. On the eastern or, rather, the southern side of this anticlinal (for its course seems to be nearly east through Acklam) the Lower Lias continues its course with minor undulations as far south as Market Weighton, in this space changing its strike, and afterwards having a dip of 2½° to 3° in an E.S.E. direction.

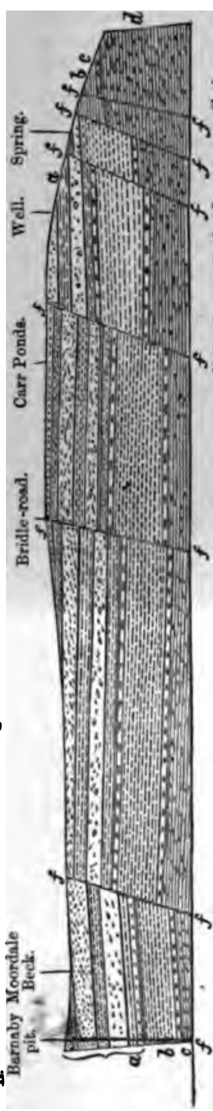
Another minor feature occurs in the broken district in the neighbourhood of Sessay, where the liassic beds lie in a long narrow trough, running out west to Topcliffe; and one end of this is seen in section there. There is also a gentle anticlinal crossing at Hotham, on the south of Market Weighton, east and west, and raising up the upper portion of the Rhætic beds.

The rocks of the Lower Lias in the tracts where they alone intervene between the Keuper and post-liassic rocks, often present a peculiar feature known as "hanging cliffs." These are steep hill-sides, on which the soft Lias-clay crops out with its scattered bands of stone, and, yielding with the moisture, gives rise to a sort of minor landslip, so that the vertical contour is, as it were, festooned. These do not seem to be related to the dip of the beds towards the valley, as they occur on the hills facing west. The chief of these are at Leppington, Bugthorpe, Givendale, and Pocklington.

Faults.

At first sight it might have been supposed that the Liassic tracts, composed of strata resting in nearly horizontal positions, would be comparatively free from faults or lines of dislocation. Such a supposition, however, would be altogether erroneous; and though the dislocations are not on so grand a scale as in the contemporary rocks in some parts of Europe, yet faults are numerous over the Cleveland Hills and adjacent districts.

The existence of some of these faults has been described or indicated by some of our predecessors. Three of them—the Peak, Whitby, and Staithes faults are mentioned, and that of the Peak illustrated by a pictorial view, in YOUNG & BIRD's 'Geological Survey.'



E Fig. 5.—*Section across Eston Moor.* W.

a. Inferior Oolite. *b.* Upper Lias. *c.* Ironstone. *d.* Middle Lias. *f.* Faults. (Scale, 6 in. to a mile.)

PHILLIPS also estimated the amounts of the dislocations of the faults previously mentioned by Young & Bird, and indicated the existence of another at Runswick.

MARLEY, in his paper, makes known the extensive dislocation which bounds the ironstone field of Eston on the south, and which will hereafter be referred to as the Upsall fault.

BEWICK traced the course of the Whitby fault, and surmised the existence of a fault at the head of Danby Dale, which we have proved.

SIMPSON, in his 'Guide to the Geology of the Yorkshire Coast' (1868), gives a horizontal section of the strata on the coast, and therein indicates the presence of minor dislocations between Staithes and Runswick, some of which are mentioned by Young and Bird.

ALLISON illustrated by a horizontal section the Westerdale fault, though its course is not marked out.

A more detailed survey than seems previously to have been made, and the opportunities afforded by the now extensive mining operations in Cleveland for an examination of some of the phenomena of stratification that would otherwise be impossible, have revealed the existence of numerous lines of fracture affecting the Liassic and Oolitic strata. The accompanying section, which very strikingly illustrates the frequency of faults in a limited area, represents a horizontal line of one mile, in a nearly east-and-west direction, crossing which in nearly parallel courses are seven faults, as proved in the Eston ironstone workings. Six of these faults throw the strata down on the east; and the aggregate amount of the throws is 350 feet.

It is very probable that a considerable number of faults traverse the Lower-Liassic plain, but of which, on account of the Boulder-covering, we have no evidence; and we may reasonably conclude that the faults are as numerous there as in the neighbouring hills, in proportion to their respective areas.

Very generally the faults affecting the sea- and inland cliffs are exposed to view, and the hade of the fault is traceable, independently of the different aspects presented on each side, by the fragmentary condition of the rocks along the line of the dislocation. In other cases the evidence for their existence rests upon the juxtaposition of strata of different ages; and in this determination a correct knowledge of the distribution of life in the Liassic formations is of the highest value and practical importance, and recommends itself to the notice of mine-owners and viewers, who, excepting a few, persistently ignore every geological principle in each new enterprise. Thus, for instance, where the *capricornus*- or *margaritatus*-shales are faulted against the grey shales (as at Brackenberry Wyke, Staithes), the upper *margaritatus*-shales against jet-rock (as at Barnaby Moor), the *Jamesoni*-shales against the alum-shales (as at Ormesby), the *Bucklandi*-shales against the *angulatus*-shales (as at Redcar), it is chiefly by the contained fossils that we are led to the discovery of the dislocation.

With few exceptions the faults are of limited length, and have a small throw; and there appears to be no relationship among them in respect of direction, though in a few localities their origin is referable to a common centre. This latter phenomenon is observable on the Redcar Scars and at Normanby. Some few of them send off one or more lateral branches, the throw of the main fault diminishing in amount by that of the successive offsets. Good examples of such exist in the south-west workings of the Normanby mine and in the Upleatham mines. In the latter example the main fault, which courses north-east and south-west, has a downthrow of 50 feet, to the east, in the south-west workings; but in its northerly extension it sends off three faults, having a small downthrow on the same side, two of which have died out before the outcrop is reached. The Upleatham fault presents an unusual feature. Where the maximum throw has been determined, the breadth of the strata disturbed by the dislocation is about 100 yards; there is no abrupt change of position, but the strata gradually decline in the direction of the downthrow, so that the pheuomenon is rather a sudden change in the direction and in the amount of dip of strata for the given breadth.

The Hummersea fault presents some features that may be useful to illustrate, which we are enabled to do by the courtesy of William France, Esq. On the front of the cliff, the line of fracture is distinctly visible, but the dislocation is inappreciable. At a distance of nearly six furlongs, measured along the south-westerly course of the fault, there is an abrupt downthrow on the south-east of 13 feet (see fig. 6), the severed faces of the strata being separated by a space of 27 feet, filled with shaly débris. The fault has been traversed again at an intermediate point, 19 chains from the cliff (see fig. 7): here neglecting an interval of 109 feet, the strata show a gentle north-easterly rise, which culminates in the Boulby anticlinal. The interval alluded to is occupied for the first 38 feet by débris; then for a length of 53 feet the strata rise rapidly to the north-east, the

maximum amount of displacement being 20 feet; two minor fractures further elevate the strata; and at a distance of 109 feet from the primary fracture the strata regain their normal position. It would thus appear that at this point the main fracture produces no actual displacement, but that the beds on the east side have subsided, which subsidence has given rise to the two supplementary faults.

Fig. 6.—*Section of Hummersea Fault*, 19 *chains S. W. from Cliff.*

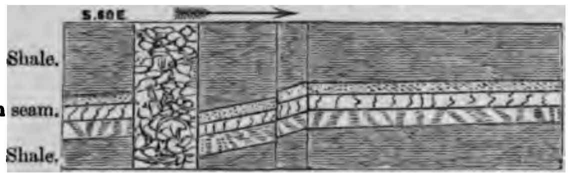
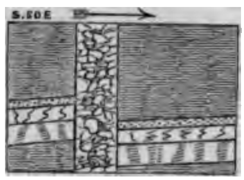


Fig. 7.—*The same*, 58·7 *chains S. W. from Cliff.*



Scale, 120 ft. to an inch.

Peak Fault.—We have little to add to the information given concerning this by Young & Bird and Phillips. It runs in a north-by-east direction; and when one stands on the shore it may be seen distinctly traversing the cliff by the side of a small point; and on the shore the line is marked by the upturned edges of the rocks on either side. Where it cuts the lower part of the cliff *Inoceramus dubius* and *Gryphæa cymbium* may be found within six inches of each other; so that the throw is the whole thickness of the Middle Lias, *i. e.* not less than 400 feet. On the scar, the two beds in contact are the top of the *oxynotus*- and part of the *margaritatus*-series. Crossing the main fault at right angles on the side of the bay is another, smaller one, with a downthrow to the south. In Robin Hood's Bay slight faults may be detected in the scars; but their throws are very insignificant, only shifting the beds by the thickness of one of them.

Whitby Fault.—The oolitic strata on the west of Whitby pier are lower than those on the east by about 75 feet. Phillips estimates it at not less than 150 feet. It is sufficient, at all events, to cut off all the Lias from the west side, the dip of which on the east soon takes it from the surface. The fault would appear to be coincident with the bed of the stream for only a short distance.

Sleights.—We have already alluded to the possible existence of

a fault of some extent at this place, as Bewick supposes, and as we have indicated on the map; but, as remarked, it may be called in question.

Runswick Fault.—The existence of this fault was indicated by Phillips, who estimated the amount of dislocation at 40 feet. Simpson refers to the same fault when he states ('Guide to the Geology of the Yorkshire Coast,' p. 45, 1868) that "near the abandoned iron-works there is a considerable dislocation of the strata, which on the south side have been thrown down 40 feet." The fault is well exposed to view in the narrow ravine of Runswick Beck, at the north end of the village, and in the cliffs overlooking the ruins of the Victoria ironworks. Its course is therefore a little east of south; and the downthrow, as measured by the relative positions of the main block of sandstone, is 50 feet, to the east; the hade is in the same direction.

Staithes District.—Between Port Mulgrave and Colburn Nab the sea-cliffs are traversed by five vertical faults, the horizontal courses of which cannot be determined on account of the diluvial cover. The most southern one, in Brakenberry Wyke, may be observed most advantageously on the beach; it throws down the main seam on the south to below the level of low water, which, on the north side constitutes a low cliff at high-water mark. Between tide-marks *Ammonites annulatus* and *A. margaritatus* may be collected in juxtaposition; the amount of the throw cannot be less than 25 feet.

The three faults which succeed to the north are insignificant; and their existence has been pointed out by Simpson and alluded to by Young & Bird.

Young & Bird indicate a fault bounding Colburn Nab on the west, with a downthrow in that direction of about 30 feet. Phillips has illustrated it by a diagram, and estimates the throw at 150 feet.

We had considerable doubt as to the existence of any dislocation at this place, believing that the dip of the strata was sufficient to account for the different altitudes at which certain bands are encountered in Colburn Nab on the west, and Penny Nab on the east. Our scepticism was overcome when, on one occasion, we were able to trace the stratification across Staithes Wyke, and encountered the clay-ironstone nodules with *Ammonites capricornus* at the foot of Colburn Nab, at a much higher level than would admit of them passing directly beneath the lowest stratum observed on the east side of the stream-course, which coincides with the line of the dislocation. The difficulty of identifying any one of the beds seen on the flat shore with those within reach in the cliff, arising from the different conditions of surface and consequent appearance, does not permit us to assign an actual amount for the dislocation; but we venture to estimate it at 20 feet.

Upleatham.—The group of faults in this hill have been already described.

Redcar.—Numerous small faults traverse the Redcar and Coatham Scars, generally making a large angle with the line of strike.

The most important one, which has been alluded to, is proved by the juxtaposition of the middle series of the "*Bucklandi*"-beds on the east, and the lowest part of the "*angulatus*"-series on the west, on the shore opposite the Battery, Redcar. The upthrow, which is on the north-west, and probably amounts to 110 feet, brings to the surface the lowest beds of the Lower Lias visible on the coast. Its course on the shore is about south-west and north-east, and coincident with the axis of the Redcar anticlinal; it has an apparent underly on the north-west. Its extent is not determinable; but the existence of *angulatus*-beds within a few feet from the surface at the undermentioned points indicates its southings:—

1. Well-sinking adjoining the railway (south side) and West Lane (west side): Boulder-clay, 8 feet; "Lower *Bucklandi*-beds," friable shales with small flat doggers, 12 feet; thin earthy limestone and hard shale, 4 feet. And at the Gas-works, 20 feet, Boulder-clay, main limestone, and shales of Jenny Leigh's Scar.
2. Bore-hole, West-Coatham Lane, 37 fathoms 1 foot, to New Red.
3. Slake's Pit, Coatham Marsh, 32 fathoms 1 foot, to Rhætic.
4. Well-sinking near West-Coatham Farm, *angulatus*-shales to depth of 32 feet (see p. 50).

The apparent thickness of the Lower and Middle Lias between Eston Nab and Eston Junction, somewhat in excess of the actual measures, may be accounted for if this fault traverses the ground between the Nab and the Eston gypsum-pit. There is no evidence that the Redcar anticlinal is continued so far to the south-west.

Eston District.—The Eston and Ormesby outliers have been subject to an unusual amount of disturbance. The faults have chiefly been determined underground; and they are so numerous that to introduce all of them in the map would render it unintelligible. They arrange themselves chiefly into two groups: one of these systems has a general direction of N.E. by E. and S.W. by W., and includes the principal ones; the direction of the other series is N.N.E. and S.S.W.; these cross fractures are of limited extent.

The main fault in the Eston workings is situated a little north of the synclinal axis that passes through the hill, and has a course nearly parallel therewith. Its maximum throw is 25 fathoms down on the south; but in the distance of one third of a mile it is reduced to 15, and finally dies out in the royalty.

The course of another and parallel one with a downthrow on the south, is traceable beyond the present limits of mine-exploitation under Eston, by the general physical features on the surface, on the line of Court-Green Beck, the main seam outcropping where the mill-race diverges from the stream. On the south of the fault the workings in the Dunsdale pit show that the fault is prolonged to the east; its throw here is about 60 feet, though its extension to Upleatham has not yet been ascertained. It thus traverses a distance of two and a half miles. A reference to the map will explain the complicated dislocations that affect and centre around Ormesby.

One of the faults is of considerable importance, that fronting the hill on the north-west. The general dip of the beds is north-west; and beneath the capping of Oolite the alum-shale crops out, forming a well-marked cliff on the north-west. A well-sinking at Long-Bank Farm proved the strata to belong to the base of the Middle Lias. A water-drift, commencing at a little lower level and driven towards the hill, revealed the same geological horizon, the fossils obtained being characteristic of the zone of *Ammonites Jamesoni*. Consequently the evidence of a downthrow fault on the north is conclusive, the amount of dislocation being measured by nearly the whole thickness of the Middle Lias, or about 300 feet. This fault seems to be bounded by transverse faults, that on its west being well marked. The evidence for the insertion of an ironstone patch on the south-west of Ormesby is the upturning of portions of the seam of ironstone by the plough; whilst the fault, which is placed to the west of it, is indicated by the hill beyond being composed of the hard beds of the "*margaritatus*"-zone, at a much higher level than the dip will carry them beneath the ironstone, and by the jet-rock proved in a pit sunk on the west side of the road leading to Ormesby.

Again, another fault transverse to the latter, as well as the others shown on the map, is traceable by the aid of the outcrops of the ironstone-seam.

Upsall Fault.—This fault is nearly parallel to the main fault in the Eston Hill, and is one of the most persistent in the district, traversing the country for a distance of at least 5½ miles. It is terminated at the west by a transverse fault deflecting some few yards to the west of Upsall Sandstone Quarry, while at the other extremity it would seem to be met by a cross fracture, which courses south-east to Stanghow, though its actual limit is as yet unknown. The existence of this fault was proved by Mr. Marley; but its course was not indicated by him. The outcrop of the ironstone on the south-west of Eston is readily traceable up to the position indicated on the map; to the east of this trial-drifts failed to reveal the presence of the seam, a sufficient reason for the insertion of the transverse fault already referred to. A pit was sunk in the plantation called Osborn Rush, a little north of the farmstead of Barnaby: the escarpment made by the main sandstone almost overhangs the site of the sinking; and the base of Oolite is seen 75 feet above. The sinking was carriedd own to a depth of 40 fathoms; and a boring was continued thence for 60 fathoms without encountering the main seam. The spoil-heap of the sinking contains the common fossils of the zone of *Ammonites Jamesoni*; and it may therefore be safely assumed that the strata excavated include the lower 240 feet of the Middle Lias, the upper 120 feet having been removed by denudation, the sinking commencing evidently below the hard beds of the *margaritatus*-series. Consequently there is here the middle part of the Middle Lias in juxtaposition with the base of the Oolite, the dislocation traversing the ground between the pit and the oolitic escarpment with a considerable downcast on

the north. The amount of the throw at the fault may be thus calculated:—

North side.	ft.	South side.	ft.
Main sandstone.			
Freestone and shales	40	Difference of level between base of freestone and surface at pit	75
Oolitic shales and ironstone ...	17	Depth of pit to level of *A. Jamesoni*................................	240
Upper Lias	218		
Main seam of ironstone, depth of *Ammonites-Jamesoni* shales	340		
Allowance for dip	10		315
	625		

Amount of throw..................... 310 feet.

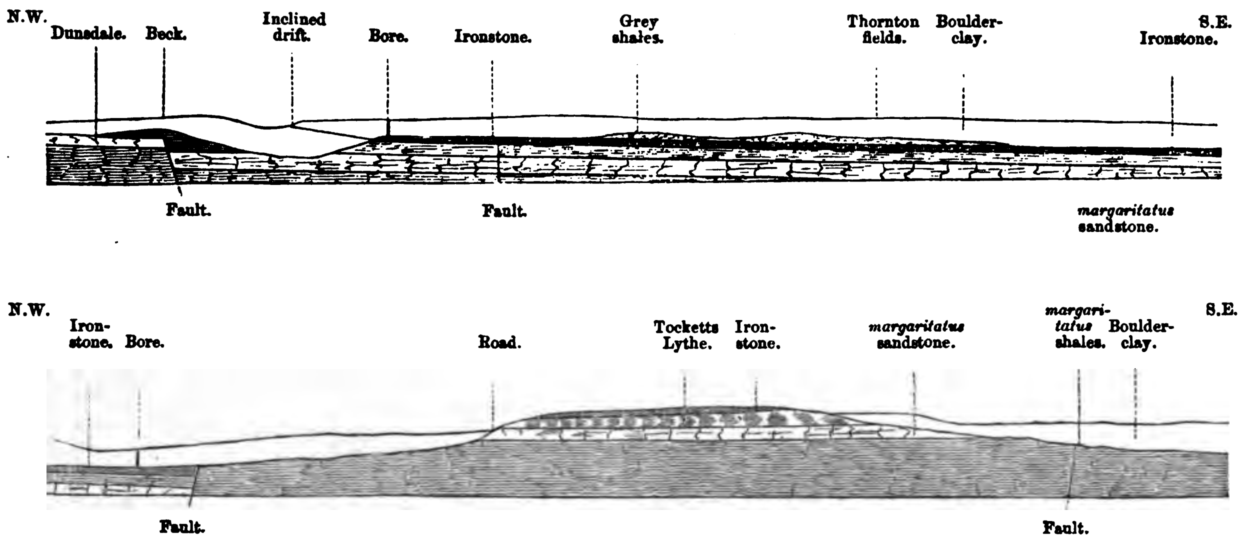
This estimate is doubtless too small by the amount of the thickness of the *Jamesoni*-beds passed through. A calculation based upon the absence of the *margaritatus*-sandstones in the pit, and possibly in the higher ground, gives about 380 feet as the amount of the throw.

The easterly extension of this fault is readily traceable at several points where the small outliers of the ironstone seam are found against the base of the Oolite and the Upper Lias. Standing at the Pinchinthorpe railway-station, and looking north, the observer cannot fail to notice a conspicuous bared surface on the slope of the hill overlooking Scugdale Farm. On close inspection the upper portion of the bank will be found to consist of flaggy sandstones of the Oolite resting against the jet-rock, whilst the shale cropping out a little lower down the bank belongs the upper *margaritatus*-beds, carrying a small mass of the main seam at one place: the chief dislocation is here accompanied by a confluent fracture of small extent, by which the jet-rock is thrown into the same horizontal plane with the Oolite and main ironstone seam. The Bank-Field bore-section, 500 feet to the south, enables us to fix approximately what part of the Oolite is brought down to the level of the ironstone; and from these data the throw is calculated at 360 feet.

Passing into the plantation on the east, two small patches of ironstone occur at a little lower level than the thick freestone of the Oolite, proving that the fault still maintains its magnitude. Another outlier of ironstone lies against the fault at a few yards west of the farmstead of Northcote; but the base of the Oolitic beds is relatively higher than at the former places. A pit known as the Challoner Pit has been sunk to the ironstone on the north side of the fault, at about a quarter of a mile to the east of Northcote Farm.

Further east, the evidence may be studied by comparing the relative position of the ironstone at Tockett's brickyard, as determined by a bore to be at a depth of 84 feet, and of the outlier crowning the knoll on the south side of the road leading from Guisborough to Upleatham. The accompanying section will illustrate the details, from which is determined the throw of 270 feet.

Fig. 8.—*Section across the Ironstone-field of Thornton and Tocketts Lythe.*



Scale, 6 inches to the mile.

Beyond this the fault is not traceable on the surface; but the throw has declined from 360 feet at Barnaby to 270 feet only at Tocketts; it may therefore be conceded that it does not disappear till after entering the Skelton valley; but it is probable that it is terminated by a cross fracture which is known to dislocate the freestone half a mile west of the village of Skelton, coursing south-east towards Boosbeck with a downthrow on the east.

Waterfall Fault.—This fault intersects the oolitic escarpment at very nearly right angles; and its downthrow is 35 feet on the north, as determined in the ironstone-workings of the Skelton pit. The evidence of the dislocation of the surface is observable in the sudden change of level of the Oolitic sandstone, proved by openings which have been made in it on either side of the fault, as also traceable by the physical features presented by this stratum, especially the outburst of springs beneath it, and the aspect of the vegetation growing upon it. The moderately sloping front of the Oolite is usually planted with fir trees, whilst the plateau-like summits of the hills are heathy wastes, sacred to grouse and dwarf sheep. Rawcliff banks are under forest culture; but the belt of plantation is suddenly interrupted and recommences at a different level, the shift in the plantation very closely coinciding with that of the underlying rock.

Stokesley Hills.—No considerable faults are known to us along the oolitic escarpment from Guisborough to Battersby Crags, or in the adjoining plain of the Lias; but the interruptions to the stratification in the latter section are so sharp, the dark alum-shale abutting against the lighter-coloured sandstone, that they may be made out from the railway which passes by at the distance of a mile.

Another prominent fault in this district is on the face of the escarpment of Greenhow Moor. Thence there is no break in the stratification till we encounter the fault which traverses Whorlton Moor, and emerges into the liassic tract on the south-west side of Whorlton Hill; it is evidently connected with a centre of great disturbance in Raisdale. Lastly, a fault intersects the cliff at Scarth Nick, with a downthrow on the west of about 75 feet, shifting the outcrop of the Oolite over 200 yards to the north, thus giving rise to that aspect in the cliff scenery which has undoubtedly suggested the denomination of "nick." Ascending to the nick by the road leading from Scarth-Nick Farm, we cross the main seam of ironstone, which has been opened upon in the wood on the east side, and of which there is a natural exposure in the stream-course on the west side of the road; and before us is a bank of jet-rock, almost overhanging which about 25 feet vertically above is a brow formed by the oolitic sandstone,—two observations which, in addition to the lateral shaft of Oolite, determine the direction and amount of throw of this fault.

Sigston Fault.—The Oolitic outlier of Borrowby is bounded on the west side by a fault, along which flows for a part of its course the Cod beck. The succession of grit, arenaceous ironstone, alum-shale, and jet-rock dipping south-west is well displayed on the scarped

face of the outlier fronting the stream; whilst the high bank on the opposite side of the beck is made by gryphite limestone, which is traceable northward by the Manor House, Sigston, to Ellerbeck. At the northern extremity of the outlier these *Bucklandi*-beds, seen near the Manor House, are in juxtaposition with the lower part of the Upper Lias, whilst at Cotcliffe Bank the base of the Oolite is at an elevation of 300 feet, dipping at a high angle towards the *Bucklandi*-beds at a height of 200 feet. The throw will therefore be equal in thickness to that of the Upper and Middle Lias and of the *oxynotus*-beds; but the absence of comprehensive sections in this district does not enable us to give a correct estimate: however, the thickness of the Upper Lias cannot be less than 150 feet; and certainly an equal amount must be adjudged to the Middle Lias.

The fault has not been traced beyond the above-mentioned place; but its declination northward is obvious, and probably comes to an end a little beyond Ellerbeck; the easterly shift of the New Red and Lias to the south of Thornton-le-Street may be accounted for by the extension of this fault in the plain of New Red, somewhere to the south of Wood End.

Thirkleby and Husthwaite Faults.—The country to the south of Thirkleby does not afford any good liassic exposures; but on crossing a low ridge (Thirkleby Barf) we find beds of the Inferior Oolite of Brandsby dipping at a high angle (1 in 6) to the E.N.E., and in Quarry Banks at a higher angle still (1 in 3) to north; a mile to the south of this we have the *margaritatus*-beds dipping south. These observations require two faults running nearly east and west, and meeting somewhere beyond Hutton Sessey.

The northern one will have the greatest throw and hade to the south, while the southern will hade to the north. Against this latter the rising beds of the Sessay synclinal must abut; and in the contrary direction we must carry it as far as Coxwold; for by the beckside there are Oolitic carbonaceous rocks and limestone dipping south-east, and the hills to the south are Liassic to an elevation of 150 feet above this level. The Lias, however, dips rapidly down to Newburgh Mill, beyond which we need not trace the fault. The whole strip of country between Coxwold and Kilburn has been let down by some enormous break-up of the strata into the very midst of the Lias, the actual amount of throw being indicated by the thickness of the whole of the Inferior Oolite, since at Coxwold even the Upper Oolites are on a level with the Lias.

Another fault may be traced to the south by Husthwaite. On the hill to the south of this the Upper Lias is at an elevation of nearly 350 feet; but 700 yards west of this we find the Oolite at an elevation of 200 feet with a gentle dip to the south-east, and nearer the railway the Oolite may be traced at an elevation of 150 feet to within the same distance of *Jamesoni*-beds at a level of 160 feet.

Easingwold.—There is evidence of a small dislocation here running east and west to little to the north of the town, in the fact of the *spinatus*-beds occurring below the 150-feet contour with Upper Lias

regularly succeeding it, while *margaritatus*-sandstone, also followed regularly by nearly horizontal beds, occur a little to the north at 225 feet; the dips observed will not account for the difference. If the occurrence of Rhætic beds near the town were confirmed, it would point to a greater dislocation to the south.

Crambe.—There can be no doubt that some dislocation affects this hill; but it cannot be said to be satisfactorily explained. It is certain that the Oolite lies on the Middle Lias at Mowthorpe, on the Lower Lias and almost the Keuper south of Crambe village, and on the Rhætic at Howsham; but at Kirkham it lies on the alum-shale with jet-rock below. The best explanation is perhaps by a preoolitic dislocation of considerable throw crossing the Derwent at Crambe, as there are no certain indications of any correspondingly large throw in the Oolite itself.

Acklam.—There is evidence of an east-and-west fault between Acklam and Leavening, with a downthrow to the north, in the very high dip to the north of the *Pleuromya*-limestones in the Moor beck; while the Red Marl a little to the south is horizontal, and the "hanging cliffs" of Acklam Wood are at a higher level than the Oolite immediately to the north.

Kirby Underdale.—A nearly east-and-west fault ranges just north of this village, which has brought down the Inferior Oolite, with the Millepore-bed, which caps Howe Hill, into juxtaposition with the Lower Lias with *Gryphæa arcuata* to the south of it. This fault is precretaceous.

Garrowby.—A fault parallel to the last runs through Garrowby Lodge, into the park, with a downthrow on the north, shifting the outcrop of the Lias by half a mile, and bringing the *Jamesoni*-beds at Bugdale Spring to a lower level than the *angulatus*-beds to the south of it. The surface also of the Lias appears to be very irregular, giving the appearance of rapid changes of dip or of dislocations to the overlying strata. Similar surface-irregularities occur at Givendale, where oolitic and cretaceous rocks appear in hollows or patches of no great superficial extent; but neither the Lias nor the Chalk supply conclusive evidences of any faults. The same irregularity may account for the various levels at which the chalk overlies the Lias at contiguous points in various other places, as North Millington, Nunburnholme, Londesborough, and Goodmanham.

Warter.—In the high dip to the east of the beds in the pit already described we have evidence of great disturbance, which, as it is not continued across the valley, must have been bounded by a fault going south and probably meeting another running south-west through the village.

South of Market Weighton.—The continuity of the range of the Lias is broken by two small parallel faults running W.S.W., the first two having a downthrow on the north, and the last to the south. The evidence for the first (at Sancton) is the sudden change of dip and the elevation of the Lias on the south of the village; for the second (at South Newbald) by the throwing back into the hill to the east of the Oolitic Millepore-beds (?) and Kelloway

rocks (a similar phenomenon to that at Sanction), and the occurrence of the ironstone nearly opposite the Inferior Oolite.

In the Dales.

The *Westerdale fault* has already been alluded to and partially described (see p. 144). It runs in a north-easterly direction, nearly parallel at first to the strike of the beds, which thus appear to gradually thin out; but it continues across the valley-end and through Castleton Ridge to the town itself, being met there by another fault. Its maximum throw must be the whole thickness of the Upper Lias, or more than 220 feet.

The *Danby fault* crosses this at an angle of about 60°, running E.S.E. Its existence is rendered probable by the low elevation of Danby Low Moor, and of the Oolite at Ainthorp, and is proved by tracing up the *margaritatus*-shales, which are nearly horizontal in Mill Scroggs, to within 100 feet distance of, and less than 20 feet below the alum-shale at the south-west side of Low Moor. Its direction is further determined by the low level of Ainthorp quarries. Its maximum threw may be about 150 feet.

The strata at the south end of Bilsdale are cut off by a cross fault, the Oolite to the south of Ewe Cote being at a much lower level than to the north, and the same sudden low appearance of rock taking place on the other side. There is also a small one near Malkin Bower with a downthrow on the south.

Raisdale and adjoining District.—The *Raisdale fault*, which has a general course of W. 6° S. and E. 6° N., is traceable on the surface for 2½ miles; and as the throw is considerable at its last appearance, it may be inferred that its actual run is much more, perhaps not less than 5 miles. The dislocation may be clearly seen in Mill Lane, above High Crosslets, in the south-west angle of Raisdale. Near the gate leading to the farm *margaritatus*-sandstones are exposed on the road-side; these are succeeded by shales with ironstone nodules; and at the edge of the moor the *main seam* crops out; and a drift put in not far off leaves no room to doubt the horizon reached; moreover the jet-rock is worked a few feet above. On the north side of the road oolitic sandstone is in juxtaposition with the jet-rock and ironstone; and the downthrow, which is obviously on the north, is calculated at 160 feet. Following the road over the dividing ridge into Scugdale, the jet-rock is continuously traceable to Rakes; but along this course the Oolite is brought down to a low level by the said fault, so that the outcrop of the Upper Lias is much narrowed at Rakes; the fault diverges into the low ground, and intersects the jet-rock, which is thrown about 75 feet; its course is no further traceable in this direction. To the east of High Crosslets the dislocation is not actually seen; but the chief observations that indicate its continuation are, the outcrop of ironstone and overlying jet-rock at Red Way on the north side, and those of the jet-rock at High West Cote and the flaggy sandstones of the Middle Lias on the road-side leading to Stony Intake, at considerably higher levels, on the south

side. The shift in the outcrop of the Oolite is not so marked; and the throw is probably about 100 feet.

Wath-Hill Fault.—This, which has a small southerly throw, passes by the north side of Wath Hill, and converges on the east towards the Raisdale fault. By this and the last fault a considerable wedge-shaped mass of oolitic sandstone is let down in the central part of Raisdale. The intersecting points of the fault are easily determined by the shifts in the jet-rock near Staindale farmstead on the west, and between Red Way and Cold-Moor Cote on the east, whilst the oolitic outlier of Wath Hill is seen to be faced on the north with alum-shale. The maximum throw is on the eastern side of the dale, and is 70 feet; at Staindale Farm it is only about 25 feet.

Another small fault is indicated by the shift in the jet-rock a few yards to the north of Staindale, which has a downthrow to the south.

Faceby Fault is probably terminated by the Raisdale fault, on the moor between Raisdale and Scugdale. The first undoubted signs of its presence are in the upper part of Snotterdale, where a small inlier of alum-shale is the consequence of the south-west downthrow of the Oolite. In the north of Faceby Bank the alum-shale may be traced till it abuts against the oolitic sandstone on the west; and the shift of the jet-rock in Faceby Plantation is also clear; the throw is here 80 feet.

In Farndale, near Esk House, there is a small fault with a downthrow on the west.

The Basaltic Dyke.

As it is doubtful if the well-known basaltic dyke which traverses Cleveland in a north-west and south-east direction be a continuation of the Cockfield Dyke, in the county of Durham, we adopt the name of Langbargh Ridge or Dyke, applied to it by Young & Bird, from the prominence it assumes in the vicinity of the hamlet of that name. It here protrudes as a wall-like mass to a considerable height above the low plain of the Lias, and originates one of the most picturesque scenes in the North Riding, especially as viewed from the south-west.

The dyke enters the county of York a little below Yarm, where it crosses the Tees; it is not traceable on the surface throughout its course of 30 miles, and abruptly ends at Maybecks on Sneaton High Moor, no traces of it thence to the sea-coast having been discovered. It is nearly vertical, and consequently shows little deviation from the rectilineal course, which is W.N.W. and E.S.E.; it is, however, shifted at a few places. Its thickness at the quarries of Preston is 70 feet, at Langbargh 40 ft.; at Egton it is about the same; but at Silhowe Cross it is diminished to about 30, and at Maybecks, its eastern termination, it is reduced to about 18 feet.

The thickness of the Boulder-clay covering is sufficient to account for its rarely appearing at the surface in the valley of the Tees;

but at certain other localities it has not penetrated the superincumbent rock; it has, however, generally succeeded in reaching to the base of the oolitic sandstone, and in parts of its course has burst through it. Consequently in its traverse through the Liassic strata we have the best opportunities for its study; and here some of the effects which it has produced upon the enveloping rocks may be best observed.

The whinstone is deposited in blocks of various sizes and shapes, generally oblong and transverse to the dyke, parallel to one another, and sometimes, as at Cliff Ridge and Ayton, assumes a rudely columnar form. The rock is usually compact and crystalline, though it is not uniform in its qualities; it exhibits in the recent fracture a rough granular surface of a blackish-blue colour, but often quite black. It is remarkably hard, and is extensively quarried in several places for paving-stones and road-material.

In no case have we observed any dislocation in the strata through which the dyke passes; and we have no unequivocal proof that the several shifts in the course of the dyke have been produced by faults. Indeed the evidence, though scanty, indicates that the basaltic intrusion was subsequent to the stratigraphical disturbances in the Liassic and Oolitic rocks.

The dyke is excavated to a considerable depth in the quarries at Stainton; and its easterly extension is traceable by the well-marked ridge it forms thence to Sunny Cross. It is now shifted half a mile to the north, and is seen as the termination of a slightly elevated ridge, which comes to an end between a farmstead a little north-east of Nunthorpe Bridge and the highroad. The knoll on the opposite side of the road, on which stands Batty's Houses, may be formed by a boss of the Whin Dyke. At its reappearance in this vicinity it undoubtedly comes through the Lias; but no actual contact is seen till we enter Nunthorpe quarries, three furlongs to the east. The ridge which the dyke makes has a north-west and south-east direction, and gradually increases in altitude above the Lias plain, and culminates in Cliff Ridge, 750 feet above the sea-level. In the Nunthorpe quarries the very nearly perpendicular walls enclosing the dyke have the slightest declination to the north, and the breadth between them is 70 feet; but here, as elsewhere, lateral bulgings are observable, which give an exaggerated thickness to the dyke. The effects of the original heated mass on the liassic strata may be well studied in the road-cutting entering the quarry on the south side; for, excepting there, the exposure of Lias is limited to the face of rock which is in actual contact. A simple induration of the calcareous shales is traceable for from 6 to 12 feet; and the parts in contact have been quite bleached, and the ferruginous ingredient has been aggregated as blotches or grains; whilst the purer argillaceous strata show little or no change.

From our starting-point, near Nunthorpe, the dyke has a straight course of nearly 1½ mile to Dingledow Quarry, where it is shifted 70 feet to the south, but in a few yards is lost beneath the Middle-Lias shales. It reappears on the east side of the railway, and in

its original course, and, rising from 400 to 750 feet elevation, constitutes the bold ridge with an almost precipitous face on the south, which forms so conspicuous a feature in this district. At the eastern extremity the dyke, which is here 65 feet thick, passes beneath the Lias, the *annulatus*-shales and the ironstone-seam wrapping around on the east and north. The alteration on the Upper-Lias shale is barely discernible; and the ironstone is not at all affected by the dyke. It is again seen at the surface in Slack's Wood, where it is quarried, but shifted a furlong to the south of its general course, which it reassumes, as it may be traced along the road leading into Lownsdale from the west. At the entrance into Lownsdale the dyke is not at the surface; but, from the altered appearance of the alum-shale, it cannot be at any great depth. Similar indications of its immediate proximity to the surface, and actual outcroppings, lead us to within a few yards of the oolitic sandstone of Coates Moor, through which the whinstone has not forced its way. On the south-east of the oolitic escarpment the dyke reappears, and thence follows a straight course for a little more than a mile, and is seen for the last time in Kildale, in a plantation between the railway and North Bank.

It emerges to the surface on Commondale Common through the oolitic rocks, and is traced by Scale Cross to Park Nook, near Castleton, where it is worked in two quarries, reaching the surface through the Oolites. Its course is now deflected a few degrees to the south; and it crosses the Esk twice in the low ground of Fryup End, and forms a slight prominence in the Oolite to the east, where it is quarried. It makes no distinct feature till it reaches Graisdale End, where it is again quarried on the surface. It here bends again to the south and is quarried near Egton Bridge, beneath Limber-Hill Wood, where it may be seen in contact with the alum-shale, which it has simply hardened. It is not seen again till we reach the Murk Esk, where it again traverses the alum-shale on the west side of the stream, and is seen in the oolitic ironstone on the east side; throughout the remainder of its course the oolitic rocks form its boundary walls at the surface.

CHAPTER XX.

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HAVING in the previous chapters given all the facts we have been able to collect, we may now profitably consider what conclusions may be legitimately drawn from them, as to the origin and nature of the deposits enumerated, and how far the series, as developed in Yorkshire, may be considered typical for the rest of England.

We have seen that the whole series obtains its greatest development in the north-western extremity of the area, and that this is especially marked in some portions, as, for example, in the ironstone, and that the decrease from this point is pretty regular. The elevation of the oolitic overlying rocks is therefore due, not only to their having been uplifted, but also to the thickening of the beds on which they rest.

Are we to suppose that the Lias extended some distance to the north-west before denudation? or that we are near its original termination in that direction when we last see it? The phenomena already described seem to point to the latter as the truth. Although the Lias in general is finely laminated and varied only by doggers or indurated bands, yet at Redcar and the surrounding country it departs largely from this character, and shows indications of the proximity of land. Even the lower parts of the series, the *Bucklandi-* and *angulatus*-beds, are less shaley than they are elsewhere, and are therefore composed of coarser and less-drifted material; and the same may be said of the other succeeding zones, until we come to that of *Ammonites margaritatus*, though but little is seen of them. The last-mentioned zone has been seen to contain numerous sandstone beds, several of which are ripple-marked, and therefore formed in shallow water. These conditions have been gradually approached in the *capricornus*-zone below, with its numerous beds of oysters and starfishes. The sandstones are by no means a limited phenomenon in the *margaritatus*-series, and seem to show that throughout the whole area the sea-bottom had been raised by deposition or otherwise until the waters were very shallow. On this succeeded an uneven depression, affecting most the south-easterly portion of the area under consideration, and possibly connected with an upheaval of the land to the north-west, bringing the shore-line of the period to no great distance from what is now Eston Moor. In the *spinatus*-beds of this locality we find the rocks highly oolitic, and, in some instances, false-bedded—circumstances

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which plainly point to an approximate and somewhat precipitous shore. Although oolitic structure is often connected with the existence of coral reefs, the débris of these appearing to furnish most freely the calcareous mud of which the Oolite grains are chiefly composed, we have no evidence of any such reefs in the neighbourhood, as during Liassic times, in Yorkshire at least, the Madreporarian fauna was a very limited one in number as well as species. We might, perhaps, look to a now removed Permian reef to the north-west; but in the absence of any such it would perhaps be safer to doubt whether such oolitic structure is in every case due to the proximity of a reef. The oolitic grains are not now calcareous; and it is by no means certain that they ever were.

The varying conditions under which the upper beds of the Middle Lias have been laid down is very well shown by the variation in the workable ironstone, and in the substitution for it of greater thickness of shale; and if, as is probable, the presence of the iron is itself due to the decay of vegetable matter, we have another indication of the littoral conditions of the north-west of the field.

Although the shore-line in the case of the Yorkshire Lias is now no longer to be seen, we have in other parts of England and Wales specimens of the actual shore preserved, as around the Mandips, in Glamorganshire, and the neighbourhood of Bristol; and in these instances it is proved by the liassic strata partaking of the character of, and sometimes becoming almost one with, the rocks on which they rest. These are at the southern end of the range of the rocks of this age; and the intermediate portion gives no such indication; so that the appearance of the same conditions at the northern extremity is instructive. However, we can scarcely say that the non-ferriferous portions of the *spinatus*-beds are continuous with beds of the same age through Lincolnshire into the rest of England, since we have seen that in the southern portion of our Yorkshire area oolitic conditions arise again, though in a minor degree, indicating at least a limitation of the Cleveland area of deposition.

With the setting-in of the Upper Lias we again encounter more open-sea conditions, introduced through the intermediation of the "grey shales," an eminently transitional set of beds; and the jet-rock and alum-shale present us, all over their area of occurrence, such a marked uniformity as of itself to mark the remoteness of any disturbing influence (such as a shore-line), which is of course confirmed by the argillaceous shaly nature of the deposits themselves. But during the deposition of these strata changes were elsewhere being brought about which at last affected the Yorkshire area—changes which appear to have been most marked towards the east, where they were foreshadowed by the *jurensis*-beds and sands of Blea Wyke, but which elsewhere came as it were suddenly on the area, caused the denudation of some parts of the old deposits, and opened up the Yorkshire area to form part of a larger one. These changes were apparently accompanied by an elevation of the sea-bottom, since in the Lower Oolites we are rapidly introduced to deposits of a freshwater character.

The source from which the Liassic materials were derived is to be looked for in the north-west; and perhaps the carboniferous series of the Pennine chain may be the most likely, aided probably by the nearer Permian rocks—the calcareous portions being derived from preexisting strata, and not originated directly from organic life, the shales being derived from those of the carboniferous series.

It seems probable that no portion of the Liassic beds was formed in very deep water, but that even the shales partook of the nature of the submerged mud flats, the doggers being precipitated carbonates of lime and of iron. The pyritous doggers, however, are due to the presence of some animal organism, which seems in almost every case to have determined their formation. The origin of the shales themselves is a difficult question. They were doubtless deposited slowly, as compared with the more rubbly and calcareous strata; and, of course, some interruption must have taken place between the formation of each layer and that of its successor. We can scarcely ascribe their separation to drying between tide-marks, an idea which every one of their phenomena would contradict. We may suppose rather that the supply of material was intermittent, and that in the interval sufficient vegetable life was present to cover the sea-bottom with a uniform carpet, through which the newly-brought material was unable to pass to join the layer beneath. In many cases this would be supplemented by animal life, whose remains, compressed between each two layers, testify to its abundance. This view of the formation of the shales derives support from the abundance of bitumen in the jet-rock, just as we find it abundant in a different form in other well-known shales—though, as in the case of the alum-shale, few indications of vegetable remains may *now* be present. It is only, however, in the alum-shale and jet-rock, of all the subdivisions except the *angulatus*-beds, that these occur.

The above remarks have reference almost solely to one portion of the area which is embraced in our account of the Lias of the county of Yorkshire, namely that portion which lies to the north and west of the river Derwent—that is, the North Riding. A careful examination of the facts recorded in our previous chapters will reveal a remarkable difference in all but the lowest beds. The soft-clay deposits of the *Planorbis*-zone, and highly calcareous and non-argillaceous character of portions of that of *Ammonites annulatus*, the absence of shales representing the *oxynotus*- and *Jamesoni*-beds, the recurrence of the oolitic ironstone, the soft clays representing the zones of *Ammonites annulatus* and *communis*, and the apparent absence of any representative, lithologically at least, of the jet-rock—all point to different conditions of formation. Shales are, indeed, known in this area, as at Hotham; but they are much more the exception than the rule. In these respects the beds here agree far more with those of Lincolnshire than with those of the North Riding, and indicate more continuous deposition, and perhaps a predominance of animal over vegetable life.

We thus have two distinct Liassic areas in Yorkshire, one forming part of a larger area to the south, and one presenting peculiar

features of its own and forming a unique whole—the two being only connected together by their basal portion, the Rhætic and lowest *Planorbis*-beds. This separation of a Yorkshire area, begun in these early Liassic times, appears to have continued throughout the Jurassic epoch, being exemplified by the characters of the Lower Oolites, and the development of Corallian and Portlandian strata.

How far, then, we may now ask, can the Yorkshire Lias be considered typical for the rest of England? Of course in this we refer to the North Riding, the Lias of the East Riding being too feebly developed for such a purpose. Does the fact of its being deposited in a basin by itself, under certain conditions, prevent it being so?

The conditions referred to are not exceptional, but are exemplified more or less in all Liassic localities: the general character of beds of this age, which has given them the name they bear, is well illustrated in our area. If we seek for more minute lithological comparisons, we shall find but few localities agreeing. The limestones vary much in character from place to place; and their position in the series is not very constant: where it is most so, as in the *Bucklandi*-zone, the Yorkshire beds agree with the rest. The impregnation of the beds with iron has no connexion with their age, but is an accidental phenomenon. The position of marlstones and sandstones, with the exception of the general observation that they lie generally towards the middle of the formation, is, as we have seen, very variable. The shaly or soft character of the argillaceous beds is seen to be dependent on locality. The Lias, then, as a whole, cannot be considered typical in lithological details in any one district, though it possesses general features which are well represented in Yorkshire. Its great thickness here, and the complete representation of every portion in one form or another, make the Yorkshire series a better exemplification of the whole deposits of the period than can be found in any other locality; and on this ground alone we might claim it as typical for England. But the great feature of the Liassic Period is its palæontology. The marked restriction of certain forms of life to particular zones, and their uniformity and constancy over wide areas, have long been remarked. No one can, of course, expect perfect uniformity; and the more distant the localities the less marked it may be. The extent of the restriction and its nature may be well judged of from our previous pages. It is exactly of the same nature as that which has proved the very life of geology: only, in the case of zones, observation has to be more careful and detailed, that the true restriction of species may be perceived; and it is then seen that zones represent a very real fact, however difficult it may be to account for. The fauna of the Yorkshire Lias is a fairly full one; and the succession of the various species, their range and restrictions, may be traced completely, as we have endeavoured to do, through the whole series; and our knowledge of the Lias of other parts of Great Britain leads us to the confident belief that the succession of life will be found to have undergone very slight and unimportant changes in going from

one end to the other of the kingdom; and the beds exhibited in any locality may be satisfactorily correlated with the corresponding zone in Yorkshire, and the succession of the zones seen to be the same.

If this be the case, if there be order in the palæontological features, and disorder in the lithological, if the succession of life is uniform and constant and the deposition of mineral matter varying and inconstant, on which of these ought we to found our classification? It is true, we have no proof that the animals of a zone in one locality were coeval with those of the same zone in another, though the succession may be the same; and if one uniform deposit were to pass from one zone of life to another in its course across the country, there would be some force in this objection. No such deposit, however, is known; and we conclude that the true method of division of the Lias is by means of these remarkable life-zones.

What is their cause? This we cannot answer. We can only say that since there is no observable difference in the mineral character of a part containing a certain Ammonite from that of a part a few feet, nay, a few inches above it, to which another is restricted, the change of life-form is not due to the surrounding physical agencies that are observable, but to some others which have left no indication of their action. They were causes, too, which acted *in spite* of the character of the sea-bottom, the change in life-forms being very little affected, in the more remarkable instances, by the change or otherwise of the matrix. *Ammonites planorbis* in the limestone may be followed by *A. angulatus* in the clay, or *vice versâ*. The change, too, is sudden, the arietan Ammonites come in in a shoal, certainly not modified or developed from others previously existing on the spot; but whence they came, and how they came to be again and again supplanted, are among the unsolved questions to which time alone can give us the answer.

The change also is more rapid in proportion to the complexity of the organization—the Cephalopoda, which stand high, being much more restricted than the lower forms, the Lamellibranchs often having a wide range, as will be noticed in our subsequent Tables. It is thus that the names of zones come to be derived from their Ammonites.

But it may be objected, of what practical use are these life-divisions? They may be theoretically interesting to the biologist; but how do they throw light on the geology proper of the district, as they are confessedly independent of the nature of the matrix? Our answer is, that it is exactly this latter feature that gives them their value. Were every portion of the Liassic series, or any other series, clearly marked lithologically, life-zones would be of biological interest only; but it is not so. Innumerable have been the mistakes made by attempting to determine the horizon of a bed, even in a limited area, by its appearance, especially from a bore-hole, and in a district where faults prevent arguments for stratigraphy being available; and it is in such cases that the knowledge of zones is most useful. Nowhere, except in the case of the coal-measures,

is this more important than in the Lias, whence so much iron is obtained; and the fossils will always tell, without fail, whether we are above or below the bed we are seeking.

We find it necessary thus to defend our method of classification, though, as is well known, it does not originate with ourselves, because there is somewhat of a tendency to consider it not well grounded in fact. Our pages will show how far it is so, and will lead any one to see that its value is not really decreased by such instances as *Ammonites margaritatus* occurring in or above the ironstone, or *A. Holandrei*, the ally of *A. communis*, in the zone of *A. spinatus*.

The more important points with respect to the distribution of the fauna will be pointed out in connexion with the Tables of fossils.

On comparing the lithological features of the Yorkshire Lias with that of other districts, we notice several points of interest. Though agreeing in general character with the Lias throughout England, it is remarkable, in the first place, for its large amount of indurated matter in the shape of ironstone, limestone, or sandstone, which may be accounted for by the proximity of the land, and which has doubtless helped to preserve the western escarpment from more rapid denudation. Again, it is throughout more shaley than any other Lias series known to us, which is also preservative of surface-features, though unfavourable for brickmaking, and for the preservation of fossils. Another feature is the great abundance of doggers, or large lumps of clay ironstone, which lie in regular beds at numerous intervals, and make excellent lines of subdivision throughout the whole thickness of the Upper and Middle Lias. Such doggers are not wanting elsewhere, but they are not so regular or numerous. Lastly, the limestones, such as they are, are always impure, and there is not a limekiln on the whole range of the formation in Yorkshire—though the cement-stones of the upper portion have been taken away for the purpose of being burnt for lime. All these features point to the prevalence of the conditions which we have endeavoured to indicate in the commencement of this chapter.

It may therefore be thought strange that we have in Yorkshire so feeble a representative of the Rhætic, and next to none of the elsewhere almost universal bone-bed, which have been generally considered indications of shallow-water deposits, especially when taken in conjunction with the absence of the Cephalopoda (*Ammonites* and *Belemnites*). This absence is as much to be noted in Yorkshire as elsewhere, and the same indications (in the layers of oysters and beds with insects) of the proximity of land; but the depression was probably more rapid in Yorkshire, and connected with another area than that which furnished the numerous bones of Aust Cliff and other Rhætic localities. Perhaps we might also expect the Rhætic beds to diminish to the north, as we have to go south for their maximum development. Our having not denoted the Rhætic beds on the map by a separate colour must not be taken as an indication that we take them to be merely a part of the Lias. They are too feebly represented to make any show on the surface,

and too seldom exposed to give any indication of their range; and they are certainly *more* connected with the Lias in Yorkshire by their common fossils and general appearance than with the Keuper, with which they would have otherwise to be combined.

Since the first part of these pages has been in print the excellent memoir of Mr. Judd on the geology of Rutland has been published in connexion with the Geological Survey, which, by describing the development of the Lias in that county and its continuation into Lincolnshire, fills up an important gap in our knowledge of the formation, as may be seen by our chapter on the bibliography, and is of special interest to ourselves in connexion with the present work, as describing the same formation in the county nearest to ours. Mr. Cross's short paper on the geology of the north of Lincolnshire, which gives an account of the Lias at Frodingham, and proves it very conclusively to be in the zone of *A. Bucklandi*, and to have no connexion whatever with that of Cleveland, has also been printed. In his memoir Mr. Judd adopts as a zone the horizon of *A. semicostatus* as distinct from that of *A. Bucklandi*. In Lincolnshire, and still more to the south, this appears to make a considerable feature in the country; so that it may be there worthy of a name. But to make use of such a term for Yorkshire would be to revive under another name the zone of *A. Turneri*, respecting which we have already given our reasons for uniting it with that of *A. Bucklandi*, at the same time noting that this zone is separable into three divisions. The same memoir contains a defence of the practice of the Geological Survey of drawing the line between the Lower and Middle Lias above the zone of *A. capricornus*, on which a few words may be said. The arguments are three:—1st. That though there may be a break where we have drawn the line, yet beds of the zone of *A. armatus* in the Midland counties appear to contain fossils both of the Middle and Lower Lias. The list of fossils, however, that is given represents the ordinary fossils of the upper part of the zone of *A. oxynotus*, especially the *A. gagateus* and *Cardinia Listeri*. The association with these in one place of *A. armatus* (perhaps from the top beds), which always occurs at the very base of the Middle Lias, is not to be wondered at, and it is the only evidence given of the mixture of faunas. 2nd. That it is impossible to draw a line in the midst of a series of clays. This might be an argument for mapping local rock-beds under local names and the rest as simply *Lias*, but will scarcely justify calling beds containing the same fossils Middle Lias when they are rocks, and Lower Lias when they are clays, as would have to be done. 3rd. That above the zone of *A. capricornus* Ammonites of that group disappear, showing a remarkable break. This is doubtless true; but the group of the Arietites are as remarkably limited to our Lower Lias, or the extreme base of the Middle (*A. tardecrescens*). We must still, therefore, maintain that the classification that is adopted for good reasons abroad, and is found to be most consistently applicable in this country, and to stand on the best palæontological grounds, is the right one.

SYNOPTICAL TABLE OF FOSSILS

FROM THE

YORKSHIRE LIAS.

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Teleosaurus Chapmanni, *König*												*	
Steneosaurus brevior, *Blake*											*		
Plesiosaurus homalospondylus, *Owen*												*	
—— macropterus, *Seeley*												*	
—— cramptoni, *Bail. & Carte*												*	
—— propinquus, *Blake*											*		
—— Zetlandi, *Phillips*												*	
—— longirostris, *Blake*											*		
—— rugosus, *Owen*			?	?									
—— brachycephalus, *Owen.*													
—— cœlospondylus, *Owen*													*
Ichthyosaurus acutirostris, *Owen*													*
—— crassimanus, *Blake*													*
—— tenuirostris, *Conyb.*												*	
—— intermedius, *Conyb.*		?	?	?	*								
—— longirostris, *Jäger*													*
Acrodus nobilis, *Agassiz*				*									
—— minimus, *Ag.*	*		*										
Hybodus reticulatus, *Ag.*				*									
—— minor, *Ag.*		*	*										
Notidanus amalthei, *Oppel*									*				
Gyrosteus mirabilis, *Ag.*												*	*
Saurichthys apicalis, *Ag.*		*											
Dapedius micans, *Ag.*			*										
Eugnathus fasciculatus, *Ag.*													
Æchmodus ovalis, *Ag.*												*	
Gyrolepis Alberti, *Ag.*		*											
Lepidotus semiserratus, *Ag.*												*	
—— rugosus, *Ag.*												*	
—— pectinatus, *Ag.*												*	
Aspidorhynchus anglicus, *Ag.*													
Ptycholepis bollensis, *Ag.*												*	
Pachycormus curtus, *Ag.*												*	

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Pachycormus gracilis, *Ag.*												*	
—— latirostris, *Ag.*												*	
—— latus, *Ag.*												*	
—— macropterus, *Ag.*												*	
—— acutirostris, *Ag.*												*	
Leptolepis saltviciensis, *Simpson*												*	
Ægoceras planorbe, *Sow.*		*											
—— Johnstoni, *Sow.*		*	*										
—— angulatum, *Schlot.*			*										
—— Charmassei, *D'Orb.*				*									
—— nanum, *Martin*			*										
—— longipontinum, *Opp.*			*										
—— Pauli, *Dum.*				*									
—— Pellati, *Dum.*				*									
—— finitimum, *Blake*				?									
—— viticola, *Dum.*				?									
—— nigrum, *Blake*				*									
—— Birchii, *Sow.*				*									
—— Scoresbyi, *Simpson*				?									
—— planicosta, *Sow.*					*								
—— gagateum, *Y. & B.*					*								
—— sagittarium, *Blake*					*								
—— raricostatum, *Ziet.*					*								
—— obsoletum, *Simpson*					*								
—— armatum, *Sow.*						*							
—— aculeatum, *Simp.*						*							
—— validum, *Simp.*						*							
—— sociale, *Simp.*						*							
—— tubellum, *Simp.*						*							
—— Taylori, *Sow.*						*							
—— Jamesoni, *Sow.*						*							
—— brevispinum, *Sow.*						*							
—— Regnardi, *Sow.*						*							
—— Heberti, *Opp.*						?							
—— Grenouillouxi, *D'Orb.*						*							
—— striatum, *Rein.*						*							
—— Henleyi, *Sow.*							*						
—— Bechei, *Sow.*						?							
—— capricornum, *Schl.*							*						
—— defossum, *Simp.*							*						
—— diversum, *Simp.*							?						
—— sinuatum, *Simp.*							?						
Arietites Bucklandi, *Sow.*					*								
—— bisulcatus, *Brug.*					*								
—— multicostatus, *Sow.*					*								
—— obesulus, *Blake*					*								
—— Brooki, *Sow.*					*								
—— Conybeari, *Sow.*				*	*								
—— spiratissimus, *Quenst.*					*								

		Lower.				Middle.					Upper		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Arietites tardecrescens, *Hauer*						*							
—— caprotinus, *D'Orb.*					*								
—— ophioides, *D'Orb.*					*								
—— spinaries, *Quenst.*				*									
—— rotiformis, *Sow.*				?									
—— Turneri, *Sow.*				*									
—— sinemuriensis, *D'Orb.*				*									
—— stellaris, *Sow.*					*								
—— obtusus, *Sow.*					*								
—— Scipionanus, *D'Orb.*				*									
—— Sauzeanus, *D'Orb.*				*									
—— semicostatus, *Y. & B.*				*	*								
—— Bodleyi, *Buck.*				*									
—— difformis, *Emm.*				*									
—— Collenoti, *D'Orb.*					*								
—— impendens, *Y. & B.*					*								
—— Macdonnelli, *Port.*						*							
Amaltheus oxynotus, *Quenst.*					*								
—— Simpsoni, *Simp.*					*								
—— trivialis, *Simp.*						*							
—— lynx, *D'Orb.*						*							
—— Huntoni, *Simp.*						*							
—— Oppeli, *Schlönb.*					?								
—— margaritatus, *Mont.*								*	*	*			
—— Engelhardti, *D'Orb.*									*				
—— spinatus, *Brug.*								*	*				
—— solitarius, *Simp.*									*				
—— ferrugineus, *Simp.*								*	*				
Phylloceras Greenoughi, *Sow.*					*								
—— Loscombi, *Sow.*						*							
—— subcarinatum, *Y. & B.*												*	
—— heterophyllum, *Sow.*											*	*	
Lytoceras fimbriatum, *Sow.*						*	*	*					
—— cornucopia, *Y. & B.*										*	*		
—— lineatum, *Schl.*											*		
—— jurense, *Ziet.*													*
—— germanii, *D'Orb.*													*
Stephanoceras annulatum, *Sow.*										*			
—— semicelatum, *Simp.*										*			
—— commune, *Sow.*												*	
—— Holandrei, *D'Orb.*									*			*	
—— Braunianum, *D'Orb.*												*	
—— crassum, *Y. & B.*											*	*	
—— Desplacei, *D'Orb.*											*	*	
—— fibulatum, *Sow.*												*	
—— subarmatum, *Y. & B.*												?	
—— fonticulum, *Simp.*											?		
—— crassescens, *Simp.*												*	
—— gracile, *Simp.*											*		

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Harpoceras algovianum, *Opp.*								*					
—— concavum, *Sow.*										*			
—— aalense, *Ziet.*											*		
—— lythense, *Y. & B.*												*	
—— simile, *Simp.*											*		
—— subconcavum, *Y. & B.*													
—— exaratum, *Y. & B.*											*		
—— cæcilia, *Rein.*											*		
—— primordiale, *Schl.*												*	
—— elegans, *Sow.*											*	*	
—— serpentinum, *Rein.*											*		
—— bifrons, *Brug.*											*	*	
—— Levisoni, *Simp.*											*		
—— latescens, *Simp.*											*		
—— striatulum, *Sow.*													*
—— compactile, *Simp.*													*
—— lectum, *Simp.*													*
—— Beanii, *Simp.*													*
—— comense, *V. Buch*													*
—— insigne *Schübl.*													*
—— rude, *Simp.*													*
Nautilus striatus, *Sow.*		*	*	*									
—— intermedius, *Sow.*					*								
—— araris, *Dum.*						*							
—— astacoides, *Y. & B.*											*	*	
—— jurensis, *Quenst*												?	
Belotcuthis subcostatus, *Münst.*											*		
—— Leckenbyi, *Blake*											*		
Geoteuthis coriaceus, *Quenst.*											*		
Teudopsis cuspidatus, *Simp.*											*		
Belemnites infundibulum, *Ph.*			*	*	*								
—— acutus, *Miller*				*	*								
—— calcar, *Ph.*				*	*								
—— penicillatus, *Sow.*				*	*	*							
—— dens, *Simp.*					*								
—— palliatus, *Dum.*						*							
—— charmouthensis, *Mayer*						*							
—— elegans, *Simp.*						*							
—— araris, *Dum.*						*							
—— virgatus, *Mayer*						*		*					
—— clavatus, *Blainv.*						*	*	*	*				
—— aspergillum, *Blake*						?	*						
—— apicicurvatus, *Blainv.*						*	*	*	*				
—— cylindricus, *Simp.*								*	*	*			
—— milleri, *Phil.*								*	*				
—— longiformis, *Blake*								*	*				
—— acuminatus, *Simp.*									*		*		
—— rudis, *Ph.*									*				
—— pollex, *Simp.*						?						*	

	Rhaetic.	Lower.				Middle.					Upper.		
		A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Belemnites microstylus, *Ph.*									*				
—— compressus, *Stahl*									*				
—— paxillosus, *Schl.*									*				
—— scabrosus, *Simp.*						?				*			
—— vulgaris, *Y. & B.*									*			*	
—— levidensis, *Simp.*												*	
—— latesulcatus, *Ph.*										*			
—— validus, *Simp.*										?			
—— striolatus, *Ph.*										*	*		
—— lævis, *Simp.*											*	*	*
—— dorsalis, *Ph.*											*		
—— subtenuis, *Simp.*											*		
—— subaduncatus, *Voltz.*											*		
—— tripartitus, *Schl.*											*		
—— elongatus, *Sow.*												?	
—— longisulcatus, *Voltz.*											*		
—— inæquistriatus, *Simp.*											*		
—— tubularis, *Y. & B.*											*		
—— crossotelus, *Blake*											*		
—— Voltzii, *Ph.*											*		
—— athleticus, *Simp.*													*
Cerithium spiratum, *Moore*			*										
—— gratum, *Terq.*			*	*									
—— semele, *Martin*			*	*									
—— Slatteri, *Tate*						*							
—— liassicum, *Moore*									*	*			
—— acriculum, *Tate*									*				
—— quadrilineatum, *Röm.*												*	
—— armatum, *Goldf.*													*
Chemnitzia transversa, *Blake*			*										
—— unicingulata, *Terq.*			*	*									
—— Berthaudi, *Dum.*				*									
—— Collenoti, *T. & P.*				*	*								
—— carusensis, *D'Orb.*						*							
—— foveolata, *Tate*						*							
—— undulata, *Benz.*						?							
—— Blainvillei, *Münst.*						*	*	*	*	*			
—— citharella, *Tate*							*	*					
—— nuda, *Münst.*								*	*				
—— semitecta, *Tate*								*	*				
—— Youngi, *Simp.*						*							
—— acuta, *Tate*										*			
Turritella Dunkeri, *Tqm.*			*	*	*								
—— Zenkeni, *Dk.*				*									
—— regularis, *T. & P.*				?	*								
Natica purpuroidea, *Tate*				?									
—— buccinoidea, *Y. & B.*											*		
Nerita alternans, *Tate*									*				
Littorina semiornata, *Münst.*			*										

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Littorina clevelandica, *Tate.*								*					
Hydrobia solidula, *Dkr.*					*								
Rissoa nana, *Martin*				*									
Eucyclus elegans, *Münst.*			*	*									
—— acuminatus, *Ch. & D.*			*										
—— Chapuisi, *Terq. & P.*				*									
—— selectus, *Ch. & D.*				*									
—— imbricatus, *Sow.*						*							
—— Guadryanus, *D'Orb.*						*							
—— undulatus, *Phil.*							*	*	*				
—— cingendus, *Tate*								*	*	*			
—— nireus, *D'Orb.*									*				
—— conspersus, *Tate*									*				
Pitonnellus sordidus, *Tate*			*	*									
Phasianella morencyana, *Piette*			*	*									
Turbo tenuis, *T. & P.*		*											
—— solarium, *Piette*			*	*									
—— Philemon, *D'Orb.*			*	*									
—— reticulatus, *Moore*				*									
—— Wilsoni, *Tate*				*									
—— cyclostoma, *Münst.*								*	*	*			
—— latilabrus, *Stoliczka*									*				
—— lineatus, *Moore*									*				
—— aciculus, *Stol.*									*	*			
Trochus redcarensis, *Tate*				*									
—— robigus, *Tate*					*								
—— thetis, *Münst.*						*							
Discohelix liasinus, *Dkr.*		*											
—— striatus, *Piette*			*	*									
—— semiclausus, *Tate*			*										
—— Oppeli, *Martin*				*									
—— aratus, *Tate*								*					
—— bellulus, *Tate*								*					
Euomphalus minutus, *Schübler*											*		
Pleurotomaria concava, *Martin*		?		*									
—— obesula, *Tate*			*										
—— similis, *Sow.*			*	*									
—— tectaria, *Tate*			*	*									
—— basilica, *Ch. & D.*				*									
—— Hennocqui, *Terq.*				?									
—— procera, *Deslong.*						*							
—— foveolata, *Deslong.*							*						
—— helicinoides, *Röm.*									*				
—— rustica, *Deslong.*									*				
—— undosa, *Deslong.*									*				
Cryptænia nucleus, *Terq.*			*										
—— rotellæformis, *Dkr.*			*	*									
—— solarioides, *Sow.*			*	*									
—— expansa, *Sow.*								*	*				

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Cryptænia consobrina, *Tate*									*				
Actæonina fragilis, *Dunker*		*	*	*	*								
—— sinemuriensis, *Martin*				*									
—— marginata, *Simp.*						*	*						
—— ilminsterensis, *Moore*							*	*	*	*			
—— chrysalis, *Tate*									*				
—— pulla, *Koch & Dk.*													*
Dentalium etalense, *Terq. & P.*			*	*									
—— limatulum, *Tate*			*	*									
—— elongatum, *Münst.*								*	*	*			*
—— giganteum, *Phillips*								*					
—— liassicum, *Moore*										*			
Ostrea liassica, *Strickland*	*	*											
—— ungula, *Römer*			*	*									
—— semiplicata, *Münst.*			*	*									
—— Goldfussi, *Bronn*				*	*	*							
—— submargaritacea, *Brauns*								*	*				
—— sportella, *Dumortier*									*				
—— subauricularis, *D'Orb.*												*	*
Gryphæa arcuata, *Lamk.*			*	*	*								
—— cymbium, *Lamk.*					*	*	*	*					
Anomia alpina, *Winkler*			*										
—— striatula, *Oppel*			*										
—— numismalis, *Quenst.*						*	*	*	*				
Pecten pollux, *D'Orb.*		*											
—— æqualis, *Quenst*		*	?	?	*								
—— textilis, *Münst.*			*										
—— textorius, *Schloth.*			*	*									
—— punctatissimus, *Q.*			*	*									
—— calvus, *Goldfuss*			*	*	*	*	*	*					
—— lunularis, *Röm.*				*	?	*	*	*	*				
—— Thiollierei, *Dumort.*				*									
—— lohbergensis, *Emers.*				*									
—— priscus, *Schloth.*					*	*	?	*					
—— substriatus, *Röm.*						*	*	*	*	*			
—— æquivalvis, *Sow.*						*	*	*	*	*			
—— verticillus, *Stol.*									*				
—— pumilus, *Lamk.*											*	*	*
—— disciformis, *Schübler*													*
Hinnites tumidus, *Ziet.*									*				
—— papyraceus, *Ziet.*												*	
Lima gigantea, *Sow.*		*	*	*	?								
—— punctata, *Sow.*			*										
—— Terquemi, *Tate*			*										
—— succincta, *Schloth.*			*	*									
—— hettangiensis, *Terq.*			*	*									
—— pectinoides, *Sow.*			*	*	*								
—— Hermanni, *Voltz.*						*	*	*	*				
—— eucharis, *D'Orb.*						*	?	*	*				

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Lima toarcensis, *Deslong.*													*
Limea Blakeana, *Tate*			*	*									
—— acuticosta, *Goldf.*						*	*	*	*	*			
—— juliana, *Dum.*						*	?	?	*				
Plicatula liasina, *Terq.*			*	*									
—— spinosa, *Sow.*						*	*	?	?				
—— calva, *Desl.*								*	*				
Avicula Pattersoni, *Tate*			*										
Monotis fallax, *Pflück.*	*	*											
—— inæquivalvis, *Sow.*		?	?	*	*	*	*	*	*	*	?	*	*
—— papyria, *Quenst.*				*	?	?	?	?	*	*			
—— calva, *Schlönb.*							*	*	*				
—— cygnipes, *Y. & B.*								*	*				
—— substriatus, *Münst.*									*	?	*	*	*
Cassianella contorta, *Portlk.*	*												
Posidonomya Bronni, *Voltz.*											*		
Gervillia Hagenovii, *Dkr.*				*	*								
—— erosa, *Simp.*						*	*	*					
Perna infraliassica, *Quenst.*			*	*									
—— lugdunensis, *Dumort.*									*				
Inoceramus pinnæformis, *Dkr.*				*									
—— **ventricosus**, *Sow.*						*	*						
—— **substriatus**, *Münst.*							*	*	*	?			
—— dubius, *Sow.*											*		
—— Simpsoni, *Tate*											*		
—— cinctus, *Münst.*												*	
Pinna Hartmanni, *Ziet.*			*	*	*								
—— folium, *Y. & B.*					*	*							
—— spathulata, *Tate*									*	?			
Mytilus aviothensis, *Buvig.*									*				
Modiola minima, *Sow.*	*	*											
—— lævis, *Sow.*		*	*	*									
—— Hillana, *Sow.*			*										
—— hillanoides, *C. & D.*			*	*									
—— bifasciata, *Tate*				*									
—— scalprum, *Sow.*					*	*	*	*	*	?			
—— numismalis, *Oppel*						*	*	*	*	?			
—— Thiollierei, *Dumort.*							*	*	*				
—— subcancellata, *Buvig.*								*					
Macrodon hettangiensis, *Terq.*		*	*	*									
—— naviculus, *T. & P.*			*	*									
—— pullus, *Terq.*			*	*									
—— intermedius, *Simp.*						*	*	*	*	*			
—— pulchellus, *Tate*						*							
—— **Buckmani**, *Rich.*								*	*				
—— clevelandicus, *Tate*									*				
Cucullæa Münsteri, *Ziet.*					*	*	*						
Nucula navis, *Piette*			*	*	*								
—— **cordata**, *Goldf.*						*	?	?	*	*			

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Leda v-scripta, *Tate*			*										
—— texturata, *T. & P.*			*	*									
—— Renevieri, *Opp.*			*	*									
—— galathea, *D'Orb.*			*	*	*	*	*	*	*	*			
—— subovalis, *Goldf.*				*	*	*	?	?	*				
—— Heberti, *Martin*					*								
—— Zieteni, *Brauns.*						*							
—— minor, *Simp.*						*	*	*					
—— complanata, *Goldf.*						*							
—— graphica, *Tate*							*	*	*				
—— ovum, *Sow.*												*	
—— æquilatera, *K. & D.*												?	*
Trigonia modesta, *Tate*						*							
—— lingonensis, *Dum.*									*				
—— **literata**, *Y. & B.*												*	*
Protocardium Philippianum, *Dk.*	*	*	*	*									
—— **oxynoti**, *Quenst.*					*	*							
—— truncatum, *Sow.*						*	*	*	*	*			
—— substriatulum, *D'Orb.*													*
Lucina limbata, *T. & P.*			*	*									
—— cardinioides, *Tate*				*									
—— pumila, *Münst.*									*				
Unicardium cardioides, *Ph.*			*	*	*	*							
—— subglobosum, *Tate*									*	?			
Tancredia ovata, *Chap. & Dew.*				*									
—— apicistriata, *Rolle*				*									
—— longicostata, *Bur.*									*				
—— lucida, *Terq.*									*				
—— broliensis, *Buv.*									*				
—— dionvillensis, *Terq.*											*	*	
Astarte obsoleta, *Dkr.*		*	*	*	*								
—— Oppeli, *Andler*			*										
—— cingulata, *Terq.*			*	*									
—— striatosulcata, *Röm.*						*	*	*	*	*			
—— rugata, *Quenst.*									*				
Cardita Heberti, *Terq*			*	*									
—— multicostata, *Ph.*						*	?	*	*				
Cardinia ovalis, *Stutch.*		*	*										
—— Deshayesi, *Terq.*			*										
—— Desoudini, *Terq.*			*										
—— crassiuscula, *Sow.*			*	*									
—— Listeri, *Sow.*			*	*	*								
—— concinna, *Sow.*				*									
—— attenuata, *Stutch.*						*							
—— antiqua, *Phil.*								*					
—— lævis, *Y. & B.*								*	*				
—— crassissima *Sow?*								*					
Cypricardia cucullata, *Münst.*						*	?	*	*	*			
Hippopodium ponderosum, *Sow.*			*	*	*	*	*	*	?				

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Hippopodium gigas, ***Tate***									*				
Myoconcha inclusa, ***Terq.***			*										
—— **psilonoti**, ***Quenst.***			*	*									
—— **decorata**, ***Münst.***							*	?	*				
Tellina fabalis, *Simp.*								*	*				
—— lingonensis, *Dum.*									*				
Venus tenuis, *K. & D.*													*
Isodonta Ewaldi, *Born.*	*												
Pholadomya glabra, *Ag.*			*	*									
—— Fraasi, *Oppel*			*	*									
—— decorata, *Ziet.*						*							
—— ambigua, *Sow.*						*	*	*	*	?			
—— Beyrichi, *Schlon.*							*						
—— Simpsoni, *Tate*									*				
—— lunata, *Simp.*									*				
—— ventricosa, *Ag.*				*	*								
Goniomya heteropleura, *Ag.*				*									
—— hybrida, *Münst.*						*	?	*	*	?			
Gresslya galathea, ***Ag.***			*	*	*								
—— **striata**, ***Ag.***						*							
—— **punctata**, ***Simp.***						*							
—— **Seebachi**, ***Brauns.***								*					
—— lunulata, *Tate*								*					
—— intermedia, *Simp.*								*	*	?			
—— donaciformis, *Ph.*												*	*
—— rotundata, *Ph.*												*	
—— abducta, *Ph.*													*
Pleuromya crowcombeia, *Moore*		*											
—— crassa, *Ag.*			*	*									
—— liasina, *Schübl.*				*									
—— Dunkeri, *Terq.*				*									
—— ovata, *Röm.*						*	*						
—— costata, *Y. & B.*						*	*	*	*	*			
—— granata, *Simp.*								*					
—— mundula, *Tate*								*					
—— rotundata, *Ziet.*										*			
—— bituminosa, *Tate*											*		
—— æqualis, *Simp.*												?	
—— contracta, *Simp.*												?	
—— elegans, *Ph.*												?	
Arcomya vetusta, *Ph.*					*	*							
—— elongata, *Rom.*						*							
—— hispida, *Simp.*								*					
—— arcacea, *Seebach*								*	*				
—— longa, *Buvig.*									*				
—— concinna, *Tate*									*				
Ceromya gibbosa, *Ether.*			*										
—— petricosa, *Simp.*								*	*				
—— bombax, *Quenst.*									*				

		Lower.				Middle.					Upper.	
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Ceromya sublævis, *Tate*									*				
—— exarata, *Tate*											*		
Thracia Grotiana, *Brauns.*							*	*	*				
—— glabra, *Ag.*												*	
Saxicava arenicola, *Terq.*			*										
——, sp.						*							
Lingula sacculus, *Ch. & D.*						*			*				
—— longoviciensis, *Terq.*												*	
Discina Holdeni, *Tate*				*									
—— reflexa, *Sow.*												*	*
Thecidea belemnitica, *Tate*						*							
Speriferina rostrata, *Schl.*			*	?	?	*							
—— Walcotti, *Sow.*				*	?	?	?	?	*				
—— oxyptera, *Buv.*						*							
—— Tessoni, *Davids.*								*					
—— signiensis, *Buv.*									*				
Terebratula punctata, *Sow.*								*	*				
Waldheimia sarthacensis, *D'Orb.*			*			*							
—— resupinata, *Sow.*									*				
—— Lycetti, *Dav.*													*
Rhynchonella plicatissima, *Quenst.*			*	*	?	*	*						
—— calcicosta, *Quenst.*						*	*	*	*				
—— tetrahedra, *Sow.*						*	?	*	*				
—— subconcinna, *Dav.*						*	?	?					
—— variabilis, *Schloth.*						*	*						
—— furcillata, *Theod.*						*							
—— rimosa, *Theod.*						*							
—— subserrata, *Davids.* ?							*						
—— acuta, *Sow.*									*				
—— lineata, *Y. & B.*									*				
—— capitulata, *Tate*									*				
—— fodinalis, *Tate*									*				
—— Bouchardi, *Davids.* ?										*			
—— jurensis, *Quenst.*													*
Buprestites bractoides, *Blake*										*			
Chauliodites minor, *Blake*		*											
Eryon Hartmanni, *Meyer*												*	
Pseudoglyphæa Etalloni, *Opp.*					?								
—— hamifera, *Blake*						*							
Glyphæa Terquemi, *Opp.*						*							
—— lyrica, *Blake*					*								
——, sp.					*			*				*	
Eryma lævis, *Blake*					*								
Bairdia liassica, *Brodie*		*	*	*			*			*			
—— dispersa, *Blake*				*						*			
—— lacryma, *Blake*			*	*									
—— redcarensis, *Blake*			*	*									
—— elongata, *Blake*			*	*									
Cythere Blakei, *Jones*		*	*										

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Cythere Terquemiana, *Jones*		*											
—— triangulata, *Blake*				*									
—— Moorei, *Jones*		*											
—— translucens, *Blake*				*	*								
—— redcarensis, *Blake*				*									
—— arcæformis, *Blake*			*	*									
Cytherella paupercula, *Blake*			*	*									
—— crepidula, *Blake*			*										
—— circumscripta, *Blake*							*						
Polycope cerasia, *Blake*			*	*									
Pollicipes alatus, *Tate*						*							
Galeolaria socialis, *Goldf.*			*	*		*							
Serpula deflexa, *Ph.*			*	*									
—— plicatilis, *Goldf.*			*			*							
—— lituiformis, *Münst.*				*									
—— limax, *Goldf.*				*				*	*				
Ditrypa capitata, *Ph.*			*	*		*			*				
—— globiceps, *Quenst.*			*										
—— cylindracea, *T. & P.*					*								
—— quinquesulcata, *Münst.*				*	*	*	*	*	*				
—— circinata, *Tate*					*	*	*	*	*				
Excavating Annelid							*	*	*				
Cidaris Edwardsii, *Wright*		*	*			*	*	*					
—— amalthei, *Qu.*									*				
Rhabdocidaris, sp.									*				
Hemipedina Tomesii, *Wr.*		*	*										
Pseudodiadema Slateri, *Blake*						*							
Uraster carinatus, *Wr.*							*						
Tropidaster pectinatus, *Forbes*							*						
Luidia Murchisoni, *Williamson*							*						
Plumaster ophiuroides, *Wr.*							?						
Astropecten Hastingiæ, *Forbes*							*						
Ophioderma Milleri, *Ph.*							*	?					
—— Gaveyi, *Wr.*						*	*						
—— carinata, *Wr.*							*						
Ophiolepis Murravii, *Wr.*				*			*	?					
Ophiurella columba, *Blake*							*						
Holothuria, sp.		*	*	*									
Pentacrinus tuberculatus, *Mill.*				*	*								
—— psilonoti, *Qu.*		*	*	*									
—— basaltiformis, *Mill.*			*	*	*								
—— Millerii, *Aust.*						*	*						
—— scalaris, *Goldf.*						*							
—— gracilis, *Charlesworth*								*					
—— interbrachiatus, *Blake*							*						
Extracrinus subangularis, *Mill.*				*				*					
—— britannicus, *Schl.*										*	*		
—— dichotomus, *M'Coy*											?		
Montlivaltia Haimei, *Ch. & D.*			*	*									

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Montlivaltia Guettardi, *Blainv.*				*									
—— polymorpha, *T. & P.*			*										
Septastræa excavata, *From.*			*										
Siphonia, sp.					*								
Onychites numismalis, *Qu.*						*							
Cornuspira infima, *Strick.*		*	*	*						*			
Miliola Scheibersei, *D' Orb.*		*											
Trochammina irregularis, *D' Orb.*		*											
—— incerta, *D' Orb.*										*		*	
—— inflata, *Mont.*												*	
Lituola agglutinans, *D' Orb.*												*	
—— globata, *Blake*		*								*			
Involutina liassica, *Jones*			*	*									
Lagena lævis, *Mont.*		*		*									
—— Natrii, *Blake*		*											
—— elongata, *Ehr.*		*	*	*									
—— ovata, *Terq.*		*											
Glandulina humilis, *Röm.*							*						
—— cuneiformis, *Terq.*			*										
—— paucicosta, *Röm.*		*		*									
Lingulina tenera, *Born.*		*	*	*	*		*			*			
—— striata, *Blake*		*											
Nodosaria radicula, *L.*		*		*									
—— raphanus, *L.*		*	*	*									
—— raphanistrum, *L.*		*	*	*		*	*			*			
—— nitida, *D' Orb.*		*					*						
Dentalina communis, *D Orb.*		*	*	*			*	*					
—— Breoni, *Terq.*		*	*										
—— oligostegia, *Rss.*		*		*						*			
—— planata, *Blake*		*								?			
—— pauperata, *D' Orb.*		*	*	*						*			
—— brevis, *D' Orb.*		*	*	*									
—— pentagona, *Terq.*										*			
—— tecta, *Terq.*		*											
—— nodosa, *D' Orb.*		*											
—— monilis, *Corn.*		*								*			
—— glandulosa, *Terq.*		*	*	*									
—— rapa, *D' Orb.*			*										
—— obliquestriata, *Rss.*			*	*									
—— funiculosa, *Terq.*					*		*						
—— burgundiæ, *Terq.*			*	*	*					*			
—— nummulina, *Gümb.*							*			*			
Marginulina reversa, *Blake*				*			*			*			
—— raphanus, *L.*		*		*									
—— picta, *Terq.*		*	*	*	*								
—— inæquistriata, *Terq.*		*	*	*									
—— Römeri, *Rss.*		*											
—— depressa, *Blake*		*		*									
—— unicostata, *Terq.*		*											

		Lower.				Middle.					Upper.		
	Rhætic.	A. planorbis.	A. angulatus.	A. Bucklandi.	A. oxynotus.	A. Jamesoni.	A. capricornus.	A. margaritatus.	A. spinatus.	A. annulatus.	A. serpentinus.	A. communis.	A. jurensis.
Marginulina Paulinea, *Terq.*	...	...	...	...	...	...	...	...	...	?			
Planularia arguta, *Rss.*	...	...	...	*									
Vaginulina legumen, *L.*	...	...	...	...	...	...	*						
—— anomala, *Blake*	...	...	...	...	...	...	*						
Cristellaria pauperata, *T. & P.*	...	*	*										
—— recta, *D'Orb.*	...	*	*	*	*	*	*						
—— major, *Born.*	...	*	*	*	*								
—— crepidula, *F. & M.*	...	*	*	*	...	...	*						
—— Bronnii, *Röm.*	...	*	*	*	*	...	*	...	...	*			
—— varians, *Born.*	...	*	*	*	*	...	*	...	...	*			
—— globifera, *Blake*	...	*	...	*	...	...	...	...	...	*			
—— rotulata, *Lam.*	...	*	*	*	*	...	*						
Flabellina rugosa, *D'Orb.*	...	*	...	*									
Frondicularia complanata, *Def.*	...	*	*										
—— lignaria, *Terq.*	...	...	...	...	...	...	*						
—— intumescens, *Born.*	...	...	*	*									
—— Terquemi, *D'Orb.*	...	...	...	*	...	...	*						
—— sulcata, *Born.*	...	*	*	*									
—— nodosaria, *Terq.*	...	*	*										
Orthocerina hæringensis, *Gümbel*	...	...	...	...	...	...	*						
—— rhomboidalis, *Blake*	...	...	...	...	...	...	*						
Polymorphina fusiformis, *Röm.*	...	*	*	...	...	...	*	...	...	*			
—— compressa, *D'Orb.*	...	*											
—— problema, *D'Orb.*	...	*											
—— nodosaria, *Rss.*	...	...	...	*									
—— simplex, *Terq.*	...	*											
—— distincta, *Terq.*	...	*											
Orbulina universa, *D'Orb.*	...	...	...	*									
Textularia agglutinans, *D'Orb.*	...	...	...	*	...	...	...	...	...	*			
Pulvinulina elegans, *D'Orb.*	...	*	*	*	...	...	...	...	...	*			
Nonionina elegans, *Wms.*	...	...	...	*									
Polystomella striatopunctata, *F. & M.*	...	...	...	*									
Nulliporites furcillatus, *Tate*	...	...	...	...	...	...	...	...	*				
Chordophyllites cicatrosus, *Tate*	...	...	...	...	...	...	...	...	*				
Equisetites, sp., ? liassicum	...	...	...	*									
Pecopteris, sp.	...	...	*										
Pachyphyllum peregrinum, *Sternbg.*	...	...	...	...	...	...	...	...	...	*	*		
Peuce Huttoniana, *Witham*	...	...	...	...	...	...	...	...	...	...	...	?	
—— Lindleyana, *Witham*	...	...	...	...	...	...	...	...	...	...	...	?	

An analysis of the foregoing list of fossils will give us data of considerable value for estimating the value of the zones, and the propriety, from a palæontological point of view, of dividing the Lias into three sections, and of drawing the lines between them where we have drawn it. Not that the results of such a comparison can be absolutely relied upon, though perhaps more so in the case of

rocks of such uniform character on the whole as the Lias than in any other case; nevertheless here also the conditions of deposit and preservation are largely to be credited with the causation of the restriction of species—as, for instance, the fishes in the jet-rock, the starfishes in the oyster-banks, and the microscopic crustaceans in beds suitable to their preservation. Yet we must not exclude one form more than another, but trust to the several errors due to this cause counteracting each other by being in the opposite direction. There are, however, thirty recurrent forms, *i. e.* species which occur in two separated zones but have not yet been found in the intervening ones. In this case, if they are not to be found there, we may leave them out of consideration, because they tend in one way to separate the zones, and in another to bind them together. We may also leave out the Foraminifera, first because their preservation may be almost called accidental, and secondly because from their low organization they are exceptionally persistent and do not participate in those changes (in such limited periods as those represented by zones) which affect the higher forms of life. We may also leave out all forms whose position is doubtful.

Table showing the Species peculiar to each Zone compared with those that pass from one Zone to the next.

Species peculiar to	Vertebrata.	Cephalopoda.	Gasteropoda.	Lamelli-branchiata.	Pallio-branchiata.	Other classes.	Totals.
Rhætic	**2**	**0**	**0**	**2**	**0**	**0**	**4**
Passage	0	0	0	4	0	0	4
Planorbis	**1**	**1**	**2**	**2**	**0**	**3**	**9**
Passage	1	2	1	6	0	5	15
Angulatus	**0**	**4**	**7**	**14**	**0**	**5**	**30**
Passage	0	3	17	24	1	13	58
Bucklandi	**2**	**17**	**14**	**12**	**1**	**6**	**52**
Passage	0	5	4	16	0	4	29
Oxynotus	**1**	**18**	**2**	**1**	**0**	**3**	**25**
Passage	0	1	0	14	0	2	17
Jamesoni	**0**	**22**	**9**	**10**	**4**	**4**	**49**
Passage	0	4	2	24	3	5	38
Capricornus	**0**	**3**	**1**	**1**	**1**	**9**	**15**
Passage	0	3	4	25	1	4	37
Margaritatus	**1**	**1**	**4**	**8**	**1**	**1**	**16**
Passage	0	8	9	32	3	4	56
Spinatus	**0**	**6**	**11**	**22**	**6**	**1**	**46**
Passage	0	2	7	12	0	0	21
Annulatus	**0**	**6**	**2**	**1**	**1**	**1**	**11**
Passage	0	2	0	0	0	1	3
Serpentinus	**16**	**22**	**2**	**5**	**0**	**0**	**45**
Passage	1	7	0	3	0	0	11
Communis	**9**	**9**	**1**	**5**	**1**	**0**	**25**
Passage	0	1	0	6	1	0	8
Jurensis	**0**	**10**	**3**	**5**	**2**	**0**	**20**

On examining this Table to see where the greatest breaks occur, and putting down in a line the numbers representing the species which pass from zone to zone, as follows,

4, 15, 58, 29, 17, 38, 37, 56, 21, 3, 11, 8,

we notice that there are two chief minima, namely, the 17 between 29 and 38, and 3 between 21 and 11. It is at these places that we have drawn the lines between the three divisions of the Lias; and it is plain that, if the series is to be divided at all on palæontological grounds, it must be at these points. Of course there are many other ways of examining the community of the faunas which which might make the distinction more clear; but in no way could we show greater community. The large proportion of all the common species is made up of Lamellibranchs, which have the widest range in time, and are therefore least useful as guides to the change of fauna. If we write down the same series of numbers for the Cephalopoda and Gasteropoda only, as follows,

0, 3, 20, 9, 1, 6, 7, 17, 9, 2, 7, 1,

we see the same minima even more marked, and certainly no sign of a minimum at the top of the zone of *A. capricornus*. Also, of the fourteen common Lamellibranchs, four range through six or more zones, four have wider ranges in the beds above, as against two that have wider ranges below.

With respect to the junction between the Middle and Upper Lias there has been less difference of opinion; and we need not, therefore, give so much consideration to it; but an inspection of these numbers will also show why we have drawn the line on palæontological grounds above the grey shales rather than below them and immediately above the ironstone as has usually been done, and as we are tempted to do by their lithological structure.

Such, then, are the evidences we can offer on paper in justification of our division of the Liassic beds of Yorkshire—a division in harmony with that necessitated by the same facts elsewhere. But these facts are felt to be much stronger in the field than they can be made on paper—because we cannot reckon rarity on paper, but it has great influence in practice.

But we must make our Tables yield us some further facts, first, with respect to the larger subdivisions, and then respecting the zones. Taking all classes of fossils and arranging them according as they are confined or otherwise to one or other division of the Lias, we find the following numbers:—

Species peculiar to the Lower Lias, 102.

Passing from Lower to Middle Lias (including some recurrent forms), 29.

Species peculiar to the Middle Lias, 224.

Passing from Middle to Upper Lias, 10.

Species peculiar to the Upper Lias, 114.

One species (*Monotis inæquivalvis*) passes through the whole range, from the lowest to the highest beds.

We have thus some idea of the necessity for a division at all, when we compare the small number of the common with the large number of the peculiar forms.

Our Table also gives the justification of the use of zones; for we see in it the large number of fossils that are peculiar to each,—not necessarily always large in comparison with the passage-forms between two where these are intimately related (as in the case of the zones of *A. Bucklandi* and *A. angulatus*, or in that of the zones of *A. spinatus* and *A. margaritatus*), but absolutely large—any zone being well characterized by these in spite of any doubt that might arise from the occurrence of passage-forms. But if we examine a little further we shall find that the passage-forms are mostly between two adjacent zones, so that they still indicate a very restricted horizon. Thus, of the 189 species that are not restricted to a single zone, 103 are restricted to two only, and 35 to three, leaving only 51 out of the whole number that have a wide range; and of these, 14 are remarkable as being limited by the exact limits of the Middle Lias, and ranging throughout all its zones. We thus see how large a majority of fossils have a smaller range than through one division, and that

we should lose much accurate knowledge but for the means of indicating smaller limits than those of Upper, Middle, and Lower Lias. We have some confidence in submitting these palæontological results as representing facts of nature, and not mere appearances due to the greater or less detail with which certain beds have been studied, because we have conscientiously given as much attention to one part of the series as another, and the exceptionally rich faunas are not due to favourable circumstances for examination. Although a careful search, such as that to which we have submitted every bed in the series, is, after all, only a very partial affair, considering the vast extent of the beds compared with their exposures on the surface, and we must be prepared to find that gaps in the succession of species will be continually filled up as different parts of the strata come to be exposed, still we may reasonably expect that this will be equally the case throughout, and that new forms peculiar to each zone as well as those passing from one to another will occur, and that the result will be the same as is indicated by the sample here presented.

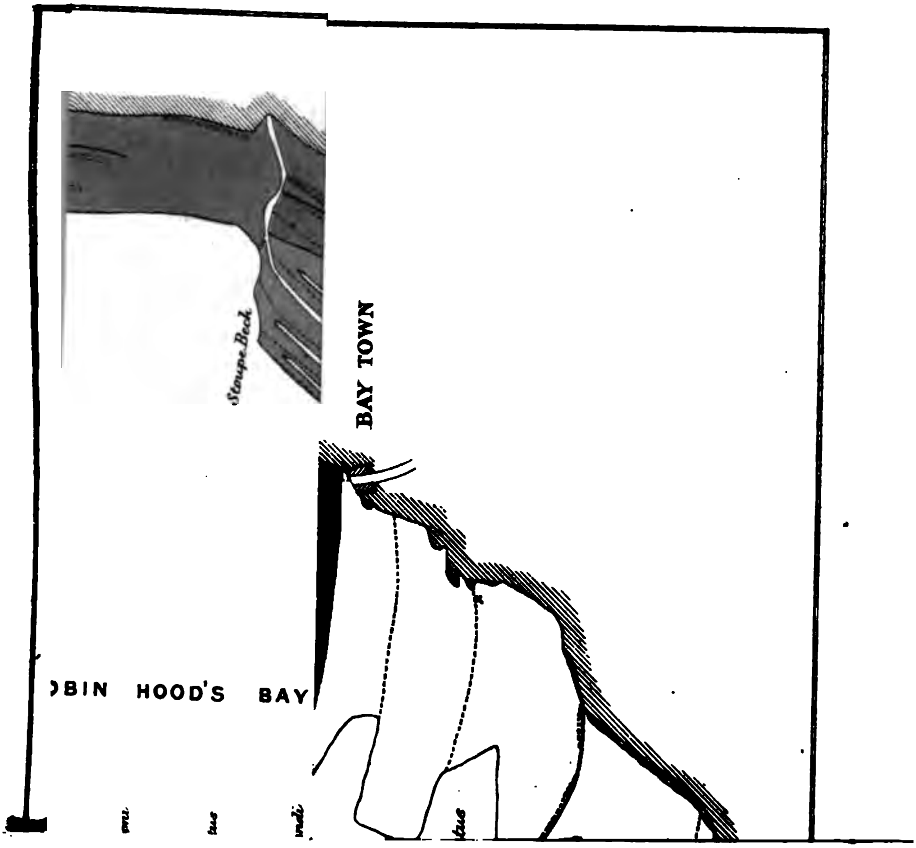
Although the vast iron industry developed in this district gives a value of its own to details connected with its supply of ore, and though, to the local geologist who would study the history of the formation of this county at every period, so that he may fully answer to himself the question of how came these features of the scenery to be formed, and to what former features have they succeeded, our statigraphical details will be of assistance, yet from a scientific point of view the history of the life of the period has the greatest value to the general geologist. By the changes in form in the animal kingdom, far more susceptible than the mineral, he must learn the past history of the more tranquil periods through which the earth has passed; and it is only by accurate information that we can be safe in generalizations that shall stand the test of time.

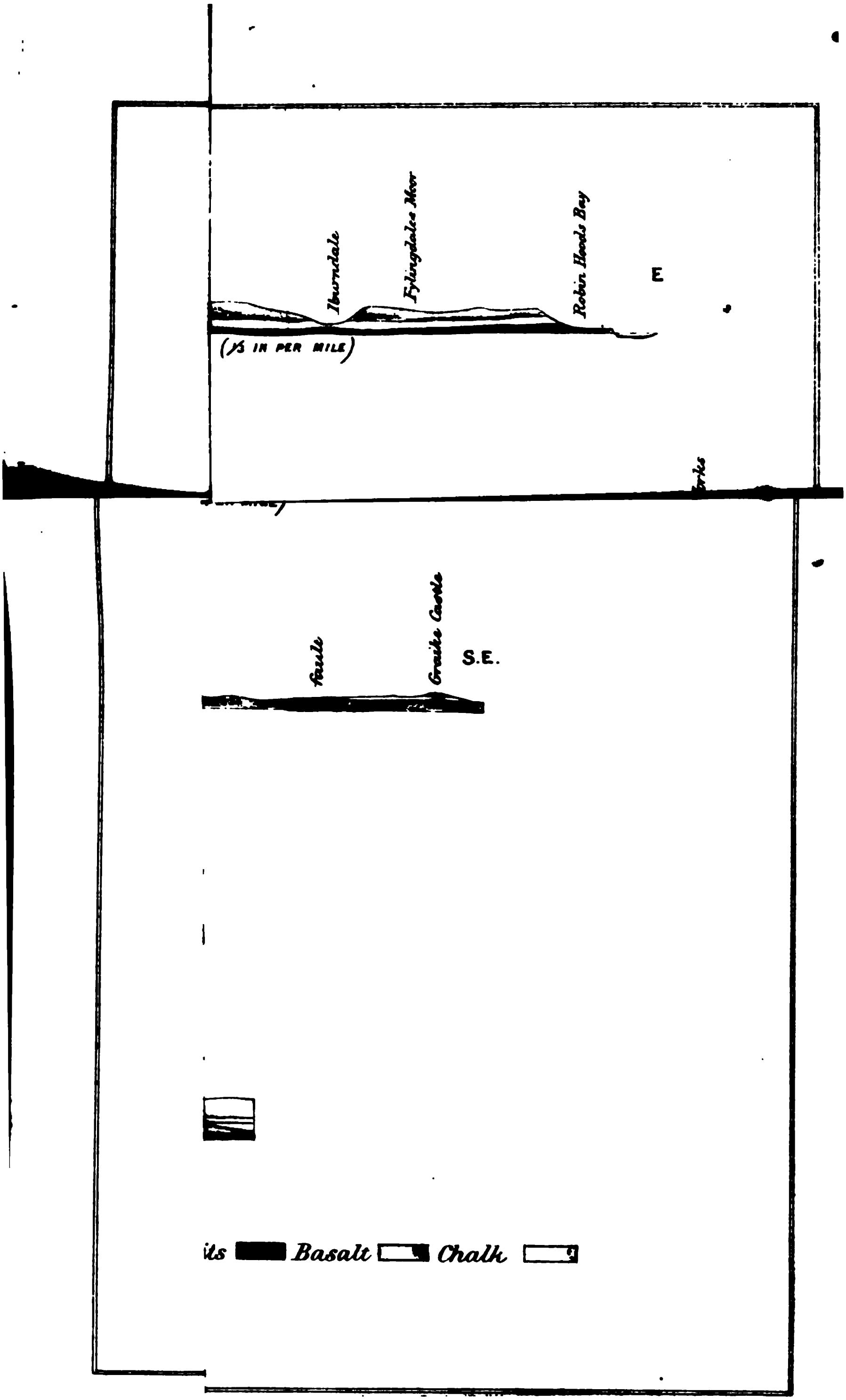
In conclusion, we would recommend the district which we have now described to any who would study an attractive portion of geology in the field. The beautiful shores of Robin Hood's Bay, with the lofty but grass-covered Peak Hill in the south, offer to the geologist continuous stores of interest along its scars when the tide is out, and a delightful picture when it is in. A ramble along the wild rocky sides of the North Cheek to Hawsker Bottom will repay a collector and charm an observer of nature. A visitor to the scars at Whitby will be certain to encounter some one (or more) tyro collecting his first fossil, where there is an unfailing supply; while at the now romantic village of Staithes he will see the very model of a Yorkshire fishing-village, and be sure to hear of a "scale-fish" (*Lepidotus semiserratus*) that has been discovered in some neighbouring jet-workings. Nor will he be less charmed with the fine headland of Huntcliff, whence he can obtain beautiful microscopic Foraminifera. If he would visit the inland valleys and find himself amongst people and in places seldom seen by the rest of the world, he will find them well worthy of his journey, though he must be prepared to rough it. Standing on the edge of one of the intervening

moors, the whole valley lies like a picture at his feet, with its double road with scattered houses, and geological features as plain as in a model, inevitably inviting a question as to the history of its denudation, which is not always easy to answer. From thence it is but a few miles to far different scenes, where mining-villages are sown broadcast, too recent to possess a name, and crowded with men who seem scarcely of the same generation as the dwellers in the secluded valleys amongst the moors. To scramble along the rocky gorges, with overhanging trees and bubbling stream below, or to jump from block to block beneath the lofty and sometimes dangerous cliffs, and to meet meanwhile with the true Yorkshire type of men, bred on their native hills, are pleasures which well repay, amidst the more arduous work of accurate observation, the out-door student of

THE YORKSHIRE LIAS.

VIEW OF THE ROCKS AT STAITHES, LOOKING SOUTH
(from a Photograph).


BAY TOWN
Stoupe Beck
BIN HOOD'S BAY


Iburndale
Fylingdales Moor
Robin Hoods Bay
E
(1/3 IN PER MILE)
S.E.
Basalt
Chalk

ORDER SAUROPTERYGIA.

GENUS PLESIOSAURUS.

Plesiosaurus homalospondylus, *Owen.*

1865. 'Palæontographical Society. Fossil Reptilia of the Lias,' pl. v.–viii.
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80).

This fully illustrated species, characterised by its long neck, small head, high cervical spines and flat vertebræ, is known by specimens, nearly complete, in the British and York Museums, and by portions of the skeleton also at Whitby.

Geological position.—Zone of *A. communis*, Whitby.

Plesiosaurus macropterus, *Seeley.*

1865. Seeley. 'Annals of Nat. Hist.,' 3rd series, vol. xv. p. 50.

This has not been figured nor described in full detail. It is labelled in the Cambridge Museum *P. grandipennis.* It differs from the last in its slightly longer neck, and in the shapes of the humerus and femur.

Geological position.—Zone of *A. communis*, Lofthouse.

There is in the possession of Mr. Brown-Marshall, of Whitby, a Plesiosaur, nearly allied to, if not identical with, the above. Its head is 9¾ inches long, and the neck is 6 feet; the total length being 16 feet 2 inches. The vertebræ are more numerous than in *P. macropterus;* and the humerus is not so broad at the distal end, being 12 inches long by only 6½ broad distally, and 3½ proximally. The femur is a little shorter and narrower proximally, but broader (6⅝ inches) distally. The radius and ulna are of peculiar shape (Pl. I., fig. 8). The interest of the specimen, however, lies in the fine preservation of its pectoral bones (Pl. I., fig. 7). The coracoids are nearly quadrilateral, and the precoracoid foramen is made entirely by them. The species therefore, whatever it is (and unfortunately neither *P. homalospondylus* nor *P. macropterus* have yet exhibited their pectoral arches), must belong to Mr. Seeley's genus *Eretmosaurus.* Should the pectoral arch of *P. macropterus* be found to differ, or the above indicated characters be considered sufficiently distinctive, I would suggest the name *P. dubius.*

Plesiosaurus Cramptoni, *Carte and Bailey.*

1862. 'Brit. Assoc. Reports,' p. 68.
1863. 'Journal of Royal Dublin Society,' vol. iv. p. 160, pl. v.
1874. *Rhomaleosaurus.* Seeley. 'Quart. Journ. Geol. Soc.,' vol. xxx. p. 448.
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80).
Syn. 1845? *P. macrocephalus.* Charlesworth. 'Brit. Assoc. Rep.,' p. 49.

This also is a complete skeleton, having a much larger head, viz. ⅛ of the skeleton, and ⅝ of the neck [the drawing gives a

smaller proportion to the head]. The total length is 22 feet 5 inches.

As the Journal quoted above is not very accessible, it may be well to note the chief characters of this species.

The skull is broad behind (1 ft. 10½ in.), gradually narrowing to 6 inches, and has a length of 3 feet 4 inches. The parietal crest is elevated (13 inches), but the whole is rather depressed. The temporal apertures are large (13 in. by 8 in.) and subquadrate. There is a small foramen behind the orbits in a median line (1¼ in. by ⅜ in.); 6½ inches in front of this is another narrower (2 in. by ⅜ in.), just behind the nasal apertures. Orbits oblique, sub-triangular (5½ in. by 4 in.): nasal apertures ovoid, each 1½ inch from the median line; ¾ inch in front of the orbits, they are 2 in. by 1 in. Muzzle slightly enlarged and rounded; the premaxillaries rough. Teeth irregularly arranged; 100–120 in all. Cervical vertebræ, 27 in 6 feet; dorsal, 30 in 8 feet; caudal, 34 in 5 feet 6 inches. The neural spines are very erect, and do not overhang the succeeding vertebræ. The centra are narrow (half their height), and not very concave. The cervical ribs articulate by two facets. The extremities are each about 5 feet in length. The femur is more expanded at the distal end than the humerus, and the tibia and fibula are larger than the radius and ulna. The ulna and fibula are not reniform, but resemble the radius and tibia. There are only 3 carpals or tarsals in a row and four digits on any hand. This latter character Messrs. Carte and Bailey regard with doubt, thinking the fifth finger may have been lost in setting. This, though not impossible, is not very probable; and Mr. Seeley regards it as sufficient when associated with the other characters to form a new genus. I have not adopted these genera in the names, for the simple reason that I think it unadvisable to do so on my own authority in a work not specially devoted to the subject.

Geological position.—Zone of *A. communis*, Kettleness.

Plesiosaurus propinquus, *Spec. nov.*

Pl. II., fig. 1.

Syn. 1863. *Macrocephalus?* Bailey and Carte, *loc. cit.* p. 169.

This species, the relative size of whose head is not very different to that of *P. Cramptoni* or *P. macrocephalus*, is proposed to be founded on the specimen exhibited under the latter name in the Whitby Museum, but to which it does not correspond in characters. Its length is 15 feet, of which its head to the articulation occupies less than $\frac{1}{6}$, and is about ½ the neck. There are 25 caudal vertebræ, occupying 4 feet 2 inches; 23 dorsal, occupying 4 feet 6 inches; and 35 caudal, occupying 4 feet 4 inches. The point of division between these regions is not very certain, but the dorsal is taken at a maximum. So far this

specimen might belong to *P. macrocephalus;* but the cervical neural spines, though not very well exhibited, certainly do not show that continuous wall of bone which is characteristic of that species. The head is triangular, $3\frac{1}{2}$ inches in the snout and 15 inches across the parietal crest. It is not very elevated in the centre, but the height cannot be measured. The skull is broken behind the orbits; the anterior margins of these are a little less than $\frac{1}{3}$ the length of the skull from the snout (their centres are $\frac{4}{11}$ of the skull from its anterior end); they are ovoid, $4\frac{1}{2}$ in. by $3\frac{1}{2}$ in., and have an interval between them of 3 inches. From the front of these the outline is quite straight to the snout The nasal apertures are small and elongate, separated by 1 inch from the orbits, and have a median foramen just behind them.

The vertebræ are not sufficiently cleared for description, but they are not so compressed as in *P. Cramptoni* or *P. macrocephalus.* Thirteen long ribs are shown on one side, two of them are lost on the other side.

Of the pectoral arch, the scapula and coracoid are well displayed. The former is about 7 inches long, and is broader inside (3 inches) than at the articulation for the humerus ($2\frac{1}{2}$ inches). It is spatulate at the broader end, oval in section at the other. The coracoid is a large bone, like a hatchet-blade, with a curved border, flattened, and almost emarginate in the middle, where also the bone is thickest. Its greatest antero-posterior diameter is 14 inches, and transverse 9 inches. It is more rounded in front than behind, where it is pointed.

The humerus is a moderately large bone, supporting a large paddle; it is 12 inches long. The anterior margin is almost straight, and the posterior only slightly concave. The distal margin is very slightly angular; the smallest breadth of the bone is $3\frac{1}{4}$ inches, the greatest 6 inches. The radius and ulna, which articulate to the two flat surfaces on the humerus, are similar shaped bones, both being narrowest in the middle; the radius is the broader bone. The length of both is $5\frac{1}{2}$ inches; but the radius is $3\frac{3}{4}$ inches in the centre, and the ulna only $2\frac{1}{2}$ inches. The ends are not much broader, but the ulna is most concave. The curves on each side of both bones are alike. There are 7 carpals—3 in the first row, 4 in the second—of a circular outline. The metacarpals are 5 elongated bones, all on the same level: the first supports 2 digits (the last curved and pointed); the second, 6; the third, 8; the fourth, 7; and the fifth, 5. The whole length from the proximal articulation of the humerus is 3 feet 8 inches. This is the only paddle preserved.

Of the pelvic arch, the pubis is a triangular bone, with one end turned up at right angles, and much thickened for the articulation of the femur; it is much smaller than the scapula. The ilium is narrow at one end (? seen in section), and swells to a large articular surface at the other, and has a length of

$8\frac{1}{4}$ inches; another narrow bone may represent the ischium seen in its breadth.

The femur is about as long as the humerus, and of a somewhat similar shape; but both margins are equally concave, and the distal end is uniformly rounded.

From this description it will be seen that this fossil differs from *P. macrocephalus* in the details of the cervical vertebræ, the shape of the humerus and the ulna, in having seven carpals, in the number of phalanges in the digits, and slightly in the general proportions of the bones. Its differences from *P. Cramptoni* have been pointed out partly by the founders of that species, and they may be ascertained by a comparison of the descriptions.

In the 'Report of the Yorkshire Philosophical Society' for 1852, it is stated that this specimen has been called *P. brachyspondylus* by Professor Owen—a proof of his recognition of its distinctness, though the name is entirely a MS. one.

Geological position.—Zone of *A. serpentinus*, Whitby.

Plesiosaurus Zetlandi, *Phillips.*

Pl. I., fig. 5.

1852. 'Report of Yorkshire Phil. Soc.' (name only).
1854. " " " "
1858. Owen. 'Report of Yorkshire Phil. Soc.' (name only).
1863. Carte and Bailey, *loc. cit.* p. 169.
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80).

The only description that this remarkable species has as yet received is the short notice in the 'Yorkshire Philosophical Society's Report' for 1854, that "in *P. Zetlandicus* (Phillips) the head is the most bulky, and the neck probably the shortest, of any known species;" and the table of measurements inserted in Messrs. Bailey and Carte's Paper for comparison with *P. Cramptoni.* I add here a few particulars, but must hope the species may sooner or later receive complete illustration. It is founded on a specimen in the York Museum.

The animal has a total length of about 19 feet, and the lower jaw occupies 3 feet 6 inches or about $\frac{2}{11}$ of the whole. Its neck is 4 feet 4 inches, or only about $\frac{5}{4}$ of the head, and contains 26 vertebræ; the dorsal region has 32 in a length of 6 feet, and the caudal 42 in 6 feet 2 inches. The skull has a lofty and strong parietal crest, 8 inches above the base, and 15 inches broad behind. The orbits are large, 3 inches in diameter; their anterior margins 11 inches behind the snout; their centres being thus at more than half the distance between the snout and parietal crest from the latter. The nasal apertures are $1\frac{1}{2}$ inches in front of the orbits, and are moderately large. The ant-orbital and post-orbital foramina on the medial line are both observable. The snout is 6 inches across; the teeth are large, more than 2 inches of them being visible.

The cervical vertebræ are almost elongated (2 inches from before behind); they are much bent, but well displayed. The neural spines are moderately long (2 inches), and very much overlap the succeeding vertebra.

The limb-bones are very large, but not many are preserved. The humerus is 20 inches long, it has a peculiar shape; the anterior side is slightly concave, but ends distally in a gentle curve, which is not produced forwards. The posterior margin is very concave, by reason of the distal end being very far produced backwards. Its breadth here is 9½ inches, and at its proximal end is 4½. The radius is rather larger than the ulna, and has its inner angles prominent; the ulna is reniform. There are three carpals, of which the two anterior are irregularly circular, and the posterior is oval (longest across the limb). The femur is as large, and somewhat of the same shape, as the humerus, but not so expanded distally.

A comparison of these characters shows that it differs from *P. Cramptoni*, its nearest ally, in having its head larger in proportion to the body, but narrower behind, and flatter in proportion to its length, and in the greater size and different shape of the humerus and the ulna, besides minor details.

This must have been the most formidable and voracious of the Plesiosaurs, its huge teeth, head, and limbs rendering it capable of tackling very large prey.

Geological position.—Zone of *A. communis*, Lofthouse.

Plesiosaurus longirostris, *Spec. nov.*

Pl. III., fig. 2; Pl. I., fig. 6.

This is founded on a specimen in the possession of Mr. Brown-Marshall, the well-known fossil collector of Whitby, which is in a very perfect state of preservation—too perfect, in fact; for as the neck and head have been confessedly put straight, having lain on the fore-paddle, some doubt is entertained (without much reason, however, I think), how far the rest is natural. Nothing, however, can alter the remarkable head, which is more elongated than that of any other species. Its nearest ally in this respect is *P. rostratus* (Owen). The bones composing it appear to have been so slender, that the orbits and temporal cavities are almost destroyed, and only the general shape is satisfactorily preserved. It has a length from the snout to the summit of the parietal crest of 20½ inches, and the angles of the lower jaw reach 3¼ inches behind this; the breadth at the snout is only 1¾ inches, and across the angles of the jaw, 8½ inches. These measurements show its excessive length, whereby it makes the nearest approach to the Teleosaurus in shape. The same alliance is shown in the rugosity of the snout, which is excessive. The length is really made by the prolongation beyond the nasal apertures. These, if rightly determined, are 2½ inches in

front of the orbits, and $8\frac{3}{4}$ inches from the snout, the breadth across the skull here being only $2\frac{1}{2}$ inches. Thus the sides for some distance are nearly parallel. Along this portion the nasal bones form a long elevated ridge, gradually coming to a point near the snout. The teeth are rather large for the slenderness of the jaw. The orbits would appear to be very elongated, but the bone is more or less broken; the parietals form a broad flat surface, without a median crest; their prolongation forward forms a very narrow bone. The skull, on the whole, is depressed. The angles of the lower jaw are formed of very strongly-ridged bones of considerable size, which seems to be in relation to the great development of side-processes on the cervical vertebræ, so as to give purchase to the strong muscles necessary to move so long a head at the end of so long a neck.

The neck, as now seen in the specimen, contains thirty-three vertebræ in a length of 70 inches, but the true number and length must be in some doubt from the restoration of this part.

The cervical vertebræ are of as great length from before behind as they are deep (2 inches). The zygapophyses and neural spine are thrown very much backwards, forming a process of peculiar shape (similar to those of *P. rostratus*) whose extreme point is vertically over the *posterior* margin of the succeeding centrum (see Pl. I., fig. 6); its height is a little more than two inches. These vertebræ were said to be very deeply cupped, in which case this may be the *P. cœlospondylus* (Owen, MS.). The side processes or cervical ribs as usual rise upon the centrum, and at the same time become longer, being almost as large as the true ribs before reaching the scapular arch—a peculiarity noticed above as connected with the long head, which we thus see must have possessed considerable mobility in a lateral and but little in a vertical direction.

The dorsal series of vertebræ are twenty-five in a length of 80 inches; the ribs give the skeleton a maximum breadth of 30 inches here. The caudal region contains thirty-two vertebræ in a length of 50 inches, the anterior twenty-one of them possess gradually decreasing side processes or caudal ribs (as in *P. homalospondylus*).

The total length is thus 15 feet 10 inches.

Portions of the bones of the pectoral arch are visible, but they are too much imbedded in the matrix to show their form or size, only that they belong to that type which is broadest transversely.

The limbs are all large, and of a similar appearance to those of *P. homalospondylus*, though differing in details; they are also larger in proportion, and the hind limb is smaller than the front one.

The humerus is $14\frac{1}{2}$ inches long, $7\frac{1}{3}$ inches broad, at the end $2\frac{5}{8}$ inches; on the shaft both borders are concave and the end is almost obtusely triangular. The radius is concave on both sides, 5 in. by $4\frac{1}{8}$ in. greatest breadth. The ulna is reniform,

5 in. by $3\frac{5}{12}$ across the middle. The first row of carpals contains three bones, of which the centre is the largest and rather angular; the front one is elongated and the back one smallest. The second row also contains three, rather smaller, more uniform in size, and nearly circular. The two outer of the five metacarpals are less advanced than the others, they support respectively the 2, 5, 6, 7, 4 phalanges. The total length is 44 inches and breadth 16 inches.

The hind limb is very similar; the femur is a little more elongated; the tibia is a little narrower for its size than the radius; the tarsals, six in number, are more alike; the second metatarsal supports only four phalanges. The total length is $41\frac{3}{4}$ inches.

The only portions of this skeleton which I can regard with much doubt are the length of the neck and the positions of the ribs and the phalangeal bones. Nevertheless, the specific name is to be considered as belonging to the head in the first instance.

Geological position.—Zone of *A. serpentinus*, Whitby.

Plesiosaurus rugosus, *Owen*.

1839. 'Brit. Assoc. Reports,' p. 82.
1865. Pal. Soc. 'Reptilia of the Lias,' p. 34
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80).

Vertebræ of this species are said by the above quoted authors to come from the Lias of Whitby, but we have not met with them. Rugosity of bone does not characterise a single species only. A tooth from the zone of *A. angulatus*, Cliff, may perhaps be referred to this species.

Plesiosaurus brachycephalus, *Owen*.

1839. 'Brit. Assoc. Reports,' p. 69.
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80).

The same may be said of this as of the last. Vertebræ with this name attached by Prof. Owen are in the York Museum.

Plesiosaurus cælospondylus, *Owen*.

1865. Pal. Soc. 'Reptilia of the Lias,' p. 12.

These vertebræ from the Whitby Museum are slightly characterised in the above memoir, and may belong to some better described species, e. g. *P. longirostris*.

Geological position.—Zone of *A. communis*, Whitby.

Plesiosaurus, *Spec. indet.*

Various Plesiosaurian remains occur in beds where whole skeletons are unknown. Those known to us may be thus enumerated:—

(*a*). An immense skeleton, some 16 to 20 feet long, was

discovered a few years ago in the ironstone mines at Eaton, but it was broken up before it was examined.

(β). Two coracoids in apposition, in the possession of Mr. W. France, of an equally large animal, were discovered in the ironstone at Skinningrove.

(γ). In the *capricornus* beds, near Saltburn, occurred a large elongated vertebra, about 3 inches long, 2 inches high, and 1¾ inches broad, with the neural spine projecting backwards. The ends were but slightly concave. Though this form is a remarkable one, we cannot derive from it sufficient characters for a specific name.

(δ). A large dorsal vertebra has been obtained from the *Jamesoni*-beds, Huntcliff.

ORDER ICHTHYOPTERYGIA.

GENUS ICHTHYOSAURUS.

Ichthyosaurus acutirostris, *Owen.*

1835. Phillips. 'Geol. of Yorkshire,' pl. xii. fig. 2.
1839. Owen. 'Brit. Assoc. Reports,' p. 121.
1875. Phillips, *loc. cit.* 3rd edit.

This is the commonest and most characteristic of the Whitby Reptiles, but it has not yet received full illustration.

Geological position.—Zone of *A. communis.* Passim.

Ichthyosaurus crassimanus, *Spec. nov.*

Pl. I., fig. 9.

1858. Owen. 'Report of the Yorkshire Phil. Soc.' (name only).
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80), (name only).
Syn. *platyodon.* Phillips, *loc. cit.*

The MS. name above quoted has been assigned to a specimen in York Museum allied to *I. platyodon.* There is another in the possession of Mr. Brown-Marshall of Whitby. The specimen at York is nearly 30 feet long, of which 6 feet 3 inches is occupied by the head, *i.e.*, about one-fifth of the whole. Its base has a breadth of 3 feet and shows well the occipital condyle. The number of vertebræ seen is eighty-six. This species differs from *I. platyodon* in the relative size of the paddles: in the latter they are equal, but in this the front paddle is the largest, being 30 in. by 12 in., whereas the hind paddle measures only 24 in. by 10 in., but they agree in great simplicity of the digital ossicles, the fore-paddles having only four rows and the hind paddles three. The vertebræ are similarly compressed; they are moderately concave and reach a diameter of 8 inches. The front vertebræ (in Mr. Marshall's specimen) exhibit the two tubercles which are seen in *I. platyodon.* The coracoid is well shown in the York specimen; it is a very bent bone, turning up almost at right angles. The humerus is a remarkable bone,

very short, and like the transverse section of a rail. The radius and ulna, unlike those of *I. platyodon*, have no concavity on their anterior borders, but are sub-pentagonal (see pl. I., fig. 9).

Geological position.—Zone of *A. communis*, Lofthouse.

Ichthyosaurus tenuirostris, *Conybeare.*

1824. 'Transactions of Geol. Soc.,' 2nd series, vol. i. t. 15, fig. 10.

Some specimens of jaws in York Museum and others with portions of the skeleton in the British Museum, coming from the Lias of Whitby, belong to this species, but their horizon is unknown.

Ichthyosaurus intermedius, *Conybeare.*

1824. 'Trans. of Geol. Soc.,' 2nd series, vol. i. t. 15, fig 9.
1839 Owen. 'Brit. Assoc. Reports,' p. 112.
1875. Phillips. 'Geol. of Yorkshire,' 3rd edit. p. 272 (80).

Professor Owen says that remains of this species occur in the Lias between Whitby and Scarborough, and from various parts of Yorkshire. The specimens we have met with in the Lower Lias belonging to animals of 7 feet and under, may possibly be referred to this. A skeleton 6 feet in length occurred in the *oxynotus*-beds of Robin Hood's Bay, but it was in too fragmentary a state to reconstruct; its teeth were moderately pointed and striated, its vertebræ ($2\frac{1}{8}$ in. by $\frac{7}{8}$ in.) very concave, and a coracoid (?) well preserved showed an emarginate inner edge, concave sides, and oval articulation for the humerus.

Geological position.—Probably the zone of *A. oxynotus.*

Ichthyosaurus longirostris, *Jager.*

1857. 'Verhandl. K. Leop. Car. Akad.,' vol. xxv. Pt. II. p. 937, tab. xxx.
Syn. ? *latifrons.* Kœnig. 'Icones Sectiles,' fig. 250.

Two specimens of this remarkable species, from the Lias of Whitby, are in the British Museum, which are, no doubt, identical with that described by Jager, as he supposes. They have very long and narrow snouts; the sides nearly parallel, with broad crowns and large orbits. In the latter characters agree so well with *I. latifrons*, which was founded on a specimen that has lost the snout, as to make it probable that they are the same species.

Geological position.—Probably zone of *A. communis*, Whitby (not *serpentinus*).

Ichthyosaurus, *Spec. indet.*

Vertebræ have occurred in the *Bucklandi*-beds at Redcar, and bones in the *planorbis* and Rhætic beds of the south part of the county.

PISCES.

BY J. F. BLAKE.

THE fishes of the Yorkshire Lias have not attracted much attention as they are, with one or two exceptions, seldom met with. No notice appears to have been hitherto taken of the isolated teeth of well-known species, which act as characteristic fossils of the strata. In the great work of Agassiz, which has formed the basis of the lists of subsequent writers—and must, to a certain extent, do the same for us—fifteen are enumerated, six of which are figured, four have short descriptions, and five are only named. One of these latter, however, may be almost considered as known, viz. the *Gyrosteus mirabilis;* Sir M. de Grey Egerton described an additional form in 1843, already quoted by Agassiz by name only, and to these Simpson has added one without description, except as to size, bringing the total to thirteen. To these we add seven species recognised by isolated teeth, and one identified with a described form, while one of the recorded ones is rejected, leaving the present total at twenty.

ORDER PLACOIDEI.

GENUS ACRODUS.

Acrodus nobilis, *Agassiz.*

1836. 'Poissons Fossiles,' vol. iii. tab. 21.

Geological position.—Several fine teeth in juxtaposition in the upper part of the Bucklandi beds, Redcar Scars.

Acrodus minimus, *Agassiz.*

1836. 'Poiss. Foss.,' vol. iii. pl. 22, figs. 6–12.

Geological position.—Zone of *A. angulatus*, Cliff; and Rhætic, near Thornton-le-Moor.

GENUS HYBODUS.

Hybodus reticulatus, *Agassiz.*

1836. 'Poiss. Foss.,' vol. iii. tab. 24, fig. 26.

Tooth only.

Geological position.—Zone of *A. Bucklandi*, Redcar.

Hybodus minor, *Agassiz.*

1836. 'Poiss. Foss.,' vol. iii. tab. 23, figs. 21–24.

Tooth only.

Geological position.—Zone of *A. angulatus*, Redcar.
Zone of *A. planorbis*, Cliff.

GENUS NOTIDANUS.

Notidanus Amalthei, *Oppel.*

1853. 'Mit. Lias Schwabens,' pl. i. fig. 1.

Geological position. — Zone of *A. margaritatus.* Robin Hood's Bay. (1 ex. Whitby Museum.)

ORDER GANOIDEI.

GENUS GYROSTEUS.

Gyrosteus mirabilis, *Agassiz.*

Pl. II., figs. 2, 3.

1836. 'Poiss. Foss.,' vol. ii. Pt. II. p. 179 (name only).

The remains of this fish consist only of bones, no teeth or scales that could be referred to it having been discovered, neither are any vertebral centra known. All these negative characters serve to unite the fish to the family of the sturgeons. The York Museum contains general specimens of different parts. Of the skull there are two pieces—one apparently belonging to the lower jaw, 9 inches long, showing the articulation, and the other one of the flat bones of an oblong shape, one portion of which is pitted with rather large holes or depressions, and the other is in longitudinal ridges, as for the overlapping of another bone; it is about 7 inches long by 3 inches in breadth. Of the bones of the extremities the chief is a large humerus (?), which is flattened at each end, but with a twist in the middle, so that the ends lie in different planes, making an angle of about 60° with each other. The whole length is about 14½ inches, and the centre of the twist is 5 inches from the smaller end; the breadth of the smaller end is 5½ inches, and of the larger 8½ inches. Considering the relative size of the corresponding bone in sturgeons, this must indicate a very large fish; smaller specimens having the same characters are known. There is a long bone, which may represent also a radius or ulna, whose ends are 1½ inches thick; the length is 9 inches, and breadth in the centre three-quarters of an inch. The most numerous of the remains are those of the fins or tail. One specimen contains indications of three or more carpal bones, followed by 22 rays, which are minutely jointed. The specimen is 8 in. by 7 in., and probably a fragment only of a fin. It is this jointed part which is most commonly found, sometimes occurring of very large size. The most interesting portion of the remains, however, is what I take to

be neural arches of the vertebræ (see Pl. II. fig. 3). Very perfect specimens of this are in York Museum, and they are also known to Mr. Simpson, who named them *Sepia incomposita*, with very great doubt as to their nature. They have, indeed, a great resemblance in shape to his *Sepia haustrum*. In section they are concave beneath and convex above, with the edges rounded off. The lower ends are produced beyond the centre, leaving a space between them. The neural canal above this rises to a ridge in a longitudinal direction, with two smaller side-ridges. About half way up two transverse ridges, slanting upwards, divide the lower part from the upper, which is more depressed, and gradually narrows to the point. At the meeting of these ridges, where they lose themselves in the centre, is a small round hole or canal. At about an inch from the upper end, where the bone has become quite narrow, there is an elevated rugosity like a collar round the bone, and the neural spine beyond has a round end, which is also more or less rough. If we compare this with the abdominal vertebra of a Sturgeon, as figured by Professor Owen ('Anatomy of Vertebrates,' vol. i. fig. 25), the similarity of structure is obvious. The transverse ridge separates the two portions into which the neurapophysis is divided in that fish. The small canal corresponds to what Professor Owen calls the "fibro-adipose canal," filled with fatty matter; and the collar and roughness of the neural spine correspond to similar features there. The length of one of these bones is 5 inches, and its greatest breadth 2 inches. The York Museum possesses a specimen containing five of such bones, following one another in a series, the concavity of one lying over the convexity of the next, which, independently of the bones themselves, gives a very good clue as to their nature.

Fragments of this fish are so commonly met with in a dogger band above the jet-bearing strata, as to have given it the local name of the "animal dogger."

Geological position.—Zone of *A. serpentinus*, Whitby.
Zone of *A. communis*, Whitby.

GENUS SAURICTHYS.

Saurichthys apicalis, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 55*a*, figs. 6–11.

Geological position.—*Rhætic* (Thornton).

GENUS DAPEDIUS.

Dapedius micans, *Agassiz.*

Agassiz records ('Poiss. Foss.' vol. i. p. 304) a *Dapedius micans* from the lias of Whitby, but gives no reference, and I have not been able to discover the specimen. Seeing that many things are brought from Lyme Regis to Whitby, and sold as

productions of the latter locality, I regard the presence of this species in our area as doubtful.

A single tooth belonging to this genus occurs in the "Planorbis" clays, Cliff.

GENUS EUGNATHUS.

Eugnathus fasciculatus, *Agassiz.*

'Poiss. Foss.' vol. ii. Pt. II. p. 105 (name only).

We have no means of knowing what specimen is referred to, although there are specimens in the York Museum which appear to belong to the genus.

GENUS ÆCHMODUS.

Æchmodus ovalis, *Agassiz, sp.*

'Poiss. Foss.' vol. iii. tab. 21, fig. 3.

Agassiz records this species as found at Whitby, and in the York Museum there is a specimen of this genus, showing the head and first half of the body corresponding with his description.

Geological position.—Zone of *A. serpentinus*, Whitby.

GENUS GYROLEPIS.

Gyrolepis Alberti, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 19.

Geological position.—*Rhætic* (Thornton).

GENUS LEPIDOTUS.

Lepidotus semiserratus, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 29*a*, and 29*b*.

This is the commonest of the Whitby Lias fishes; well-preserved specimens showing all the parts are in many museums. A specimen in my collection shows part of the ribs, whose proximal end is much expanded, and almost bifurcate.

Geological position.—Zone of *A. serpentinus.* Passim.

Lepidotus rugosus, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 33*a*, figs. 1–8.

All the bones and scales in this species are rugose. A head and some scales are preserved in Whitby Museum.

Geological position.—Zone of *A. serpentinus*, Whitby.

Lepidotus pectinatus, *Egerton.*

1843. 'Memoirs of Geol. Survey of Great Britain,' decade 6, pl. vii.
Agassiz. 'Poiss. Foss.' vol. ii. p. 305.

A unique specimen with pectinated scales. Size 9 in. by 2¾.

Geological position.—Zone of *A. serpentinus*, Whitby.

GENUS ASPIDORHYNCHUS.

Aspidorhynchus anglicus, *Agassiz.*

'Poiss. Foss.' vol. ii. Pt. II. p. 139 (name only).

This fish, of which I have not seen a specimen, is recorded only by the author above quoted, as from the Lias of Whitby (see next species). The original is in the possession of Sir Malpas de Grey Egerton, Bart.

GENUS BELONOSTOMUS.

Belonostomus acutus, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 47*a*, figs. 3–4.

Has very long sharp-toothed jaws.

Geological position.—Zone of *A. serpentinus.*

I think it very probable that these may be Lyme Regis fossils sold at Whitby. Such is the case with the specimen in the British Museum said to come from Whitby.

GENUS PTYCHOLEPIS.

Ptycholepis Bollensis, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 58*b*.

A fine specimen of the front half of this fish is in the York Museum, showing the characteristic crinkled scales.

Geological position.—Zone of *A serpentinus*, Whitby.

GENUS PACHYCORMUS.

Pachycormus curtus, *Agassiz.*

'Poiss. Foss.' vol. ii. tab. 59.

This is the only species of this genus that Agassiz figures from the Yorkshire Lias. It is tolerably common, and is found in all the local museums.

Geological position.—Zone of *A. serpentinus*, Whitby.

Pachycormus gracilis, *Agassiz.*

'Poiss. Foss.' vol. ii. Pt. II. p. 114.

Agassiz's only description of this is that it is near *P. curtus*, but more delicate; the tail has very fine rays and is broadly forked. The specimen, however, on which these observations are founded is in the York Museum, and is well characterised.

Geological position.—? Zone of *A. serpentinus*, Whitby.

Pachycormus latirostris, *Agassiz.*

'Poiss. Foss.' vol. ii. Pt. II. p. 114.

This is another unfigured and shortly described species. The description is "very large, with short head and pointed snout."

A specimen in the York Museum is conjecturally identified as this, as it corresponds to the above description. It consists of a head only, which is remarkable for the large opercular bones.

Geological position.—? Zone of *A. serpentinus*, Whitby.

Pachycormus latus, *Agassiz.*

'Poiss. Foss.' vol. ii. Pt. II. p. 114.

The only description is, "very large and oblong; head short and small." The type is in Lord Enniskillen's collection.

Geological position.—Zone of *A. serpentinus*, Whitby.

Pachycormus macropterus, *Agassiz.*

'Poiss. Foss.' vol. ii. pl. 59*a*.

This is not recorded by Agassiz as from the Whitby Lias, but a specimen in the York Museum with an elongated head and large pectoral fin seems to agree fairly well with his description of that species.

Geological position.—Zone of *A. serpentinus*, Whitby.

Pachycormus acutirostris, *Agassiz.*

'Poiss. Foss.' vol. ii. Pt. II. p. 114.

The only diagnosis is this—"with pointed snout, fine teeth, very sharp." I have seen no specimen of such a fish and cannot illustrate it further. Having, however, a description it must remain on the list.

Geological position.—Probably the same zone as the others.

NOTE.—There is a specimen in York Museum which corresponds to the short description of *P. latipennis*, given by Agassiz 'P. F.,' vol. ii., pt. II., p. 114.

GENUS LEPTOLEPIS.

Leptolepis saltviciensis, *Simpson, sp.*

Pl. III. fig. 1.

'Fossils of Yorkshire Lias,' p. 19.

Although the small fishes alluded to by Simpson have not been discovered with their scales, but only their skeleton is known, there can be little doubt of their being ganoid, and belonging to the genus Leptolepis, with which they correspond in every other particular. The pectoral, ventral, and anal fins are about the same size, and are at equal distances apart. The dorsal is rather large, and is situated opposite the interval between the anal and ventral. The vertebral column is ossified, and the tail homocercal. The head is small and the teeth are comparatively large, and lie apparently in clumps. Length 4 in. by $\frac{3}{4}$ in.

Geological position.—Zone of *A. serpentinus*, Whitby.

CLASS CEPHALOPODA.

BY J. F. BLAKE.

ORDER TETRABRANCHIATA.

FAMILY AMMONITIDÆ.

Introduction.—The genus *Ammonites* has now become quite of Linnæan dimensions, and almost constitutes a family, and the vast series of species may be well arranged in groups that have the value of more modern genera. Long ago they were divided into families by Von Buch—families within a genus! But this grouping has not been allowed to affect the nomenclature. Among German palæontologists, however, a new system has been inaugurated of definitely cutting up the series into genera, to which names have been assigned. This system does not appear to have been as yet adopted in England; partly, perhaps, from the want of an introduction, but partly, no doubt, from the fact there is something *sui generis* about the *Ammonite* which makes us loth to part with an old and expressive name. Yet, from a philosophic point of view, the retaining so large a group under one name cannot be defended in the face of the splitting up of the *Trilobites*, for instance, into numerous genera, and of the partial dismemberment of the Ammonite group itself by the formation of genera such as *Crioceras* or *Toxoceras*, on the mere decrease of involution, which is not constant within the limits of the genus *Ammonites* as retained. By way, therefore, of introducing the new nomenclature into use in this country, I have attached to each species, while retaining the generic name Ammonites in the lists, the name of the new subdivision to which it belongs, so far as these divisions are established. It must, however, be remarked, that English specimens are seldom so perfect as to indicate the features on which the new genera are founded, and we have, therefore, largely to rely on foreign information.

As an additional means of drawing attention to these genera, I may be allowed to make some introductory remarks on what must now be called the Family of AMMONITES, and I will consider in order the various features on which their classification must depend.

Like all the conchiferous mollusca, they have a shell, which consists essentially of a cone, more or less rolled up in one plane or in a spiral. If we take any fixed point in relation to the

shell, say a point in its surface, or in the centre of its aperture, that point will describe a curve with the growth of the shell; and if this curve be projected on a plane, it nearly forms the well-known "equiangular spiral;" not exactly, however, because the growth does not begin from a point, as it should, but from the circumference of the embryo; and it has, therefore, been proposed by Mr. Naumann to call it a "concho-spiral." Taking, however, the former curve as an approximation to the form produced, we know that this depends for its shape entirely on the "angle" at which it is bent; and this depends on the law of growth of the shell. Now, since this law is the same for all the parts of the shell, it follows that the curve described by every point in the same plane is the same, only representing earlier or later portions of one and the same curve. If, therefore, in an ammonite, which is coiled in one plane, it is necessary to go back an exact revolution, or 360°, to reach the part of the curve corresponding to the inner edge of the whorl, it is plain that this will be just in contact with the outside of the preceding whorl, which is also an exact revolution behind. If we must go back farther, the inner edge of the last whorl will lie *within* the outer edge of the preceding, or the shell will be more or less involute; if, on the contrary, we have to go back less, it will be uncoiled. The shape, then, of any shell coiled in one plane depends on the magnitudes of two angles, viz., the angle of the spiral, and the angle of retardation of the inner edge. There are two other elements which can enter into the formation of any shell—the angle of elevation out of the plane, and the form of the transverse section. Leaving this last out of consideration, it is interesting to see how the other three angles produce the different shells, *e.g.*, a small spiral angle and small retardation—a *dentalium* or *toxoceras*; a small spiral angle and great retardation—a *brachiopod*; the same with a small angle of elevation—a *lamellibranch*.

Our present point, however, is this—the simple fact of the angle of retardation of the inner edge being less than 360°, has given us the genus *Crioceras*, and, being *much* less, *Toxoceras*; it is, therefore, with great reason that its being exactly 360° greater, or much greater, should equally characterise genera. What I call the angle of retardation, obviously depends simply on the ratio of the rate of growth of the inner edge to that of the outer.

One more point depending on these angles: — the genera *Scaphites* and *Ancyloceras* simply contain those species in which the spiral angle is *decreased* at a certain period of life, so that the whorl grows *away* from the centre. Why, then, should not these forms be considered worthy of distinction in which the spiral angle *increases*, and the whorl comes near the centre, the aperture generally decreasing, as in the proposed genus *Ækotraustes*.

The next varying feature is the general shape and ornament of the shell, on which I have no general remarks to make.

except that this must largely serve in any classification to assist in determination of alliances.

The next feature on which great stress has been laid is the form of the sutures. That we may rightly estimate the amount of importance to be attached to these, we must have some idea of their use and mode of formation; and also with respect to the siphuncle, whose position has been found distinctive of great families. In the first place, the more complicated lobes of the Ammonite, as compared with those of the Nautilus, seem obviously designed to support a thinner and less resisting-shaped shell, and one belonging probably to a more active animal, the intricate ramifications making an excessively long line of support to the interior of the shell in a comparatively limited area. But there is another peculiarity more difficult to account for, first noticed, I believe, by Quenstedt, and it is this. In the Nautilus proper the last septum, which bounds the body-chamber behind, is concave towards the aperture; but in the Ammonite it is, upon the whole, convex; and in intermediate genera—*Clymenia*, *Aturia*, *Goniatites*—it is difficult to say which it is, being partly one and partly the other in about equal proportions. What is the cause of this difference? The shelly septum is of course formed upon the model of the hinder edge of the soft mantle, which yields to pressure; and since when a soft substance is subjected to pressure it must *necessarily* be concave towards that side on which the pressure is greatest, it follows that in the Nautilus the pressure on the mantle is greatest from the outside, but in the Ammonite it is greatest from the inside; while in the intermediate genera the difference is but small. Now, if we look at the lobes of any Ammonites, we find that all the points are directed from the aperture, and the concavities, or rounded parts, are directed *towards* it. We thus see the mode of their formation. The long circumference of the mantle—too long to form simple sutures, as in the Nautilus—is forced forward by a pressure from behind; those parts which hang back and cling to the shell form the points, and the intermediate parts that give way form the "saddles." Whence, then, comes this pressure? It is certain that the chambers of the Nautilus are filled with a gas of some kind, which must of course be secreted by the mantle; and it must have been the same in the Ammonite. If little of this air were secreted, it would be at less pressure than that to which the body of the animal was subjected, as in the Nautilus. If the quantity of this air were increased, or the pressure on the body diminished, then we should have the case of the Ammonite, and the difference of the sutures *may* point either to increased secretion of air in the latter, or a more active life on the surface of the ocean. In either case we see an additional reason for the strengthening of the shell by the complication of the sutures, because it has to support a pressure from within. We can thus trace the history of the formation of a new partition. After the formation of the last, the animal

grows forward in its shell, at the same time that the ovaries distend in the hinder part, and occupy the place deserted by the other organs, until at last they occupy the whole space that will intervene between the two septa. But how are the ova to be extruded when mature? We cannot say by the simple contraction of the mantle or other muscular bands surrounding the ovisacs, because the remainder of the animal does not retract again into the space which is thus left vacant. Before, therefore, the ova can be extruded, something must be secreted to take their place, and this can be nothing else than some kind of gas, which alone at last occupies the interval between the septa, and to relieve the pressure of which the latter are formed. If this be the true account of the formation of the septa, the particular details, as distinguished from the general form of the sutures, will be quite a secondary matter, depending rather on the internal form of the shell, and determined to a great extent by simple mechanical laws; while the position of the siphuncle is obviously a matter much more intimately connected with the particular organisation of the soft parts.

The other observable features of an Ammonite have only recently attracted their due attention. I will consider next the presence or absence and the nature of the *Aptychus*. First, as to its nature and use. Two theories have been broached with respect to it—1, that it is an operculum; and 2, that it forms a protector to the nidamentary gland. It may be considered certain that in some instances at least it acts as an operculum, because specimens have been found in which it accurately fits the aperture, and stands in it perpendicularly. See 'Woodward's Geologist,' 1860, p. 328; Oppel, 'Palæontologische Mittheilungen,' tab. 72; 'Bull. Geol. Soc. France,' 1870, p. 10. That it does not often do so is no argument that it was not an operculum, because we know that many gasteropods have opercula that only partially close the aperture. The general position of the Aptychus, as found in the fossils, is towards the ventral side (outside), a little way from the mouth; in fact, exactly covering the spot in which are the nidamentary glands in the Nautilus. From this it is inferred by Waagen that their object must be to protect the nidamentary gland of the Ammonite; and he assumes that they are formed by the gland itself, by a deposition of shelly matter in the tissues. Dr. Gray, in a stricture upon a paper by A. Favre in the 'Ann. & Mag. of N. H.,' May, 1873, objected to this idea, because only two Molluscs are known to form shelly substances in their soft organs other than the mantle or foot. And there is considerable weight in this objection, when we know that in these exceptions the hard body is not of true shell-structure, as in Aptychus, which has a structure like that of an operculum. The Aptychus might, however, be formed by the *mantle* for the protection of the nidamentary gland; but if their normal position is thus within the shell, close beneath its ventral side, we may well ask, what need to protect an organ

already protected by the shell? It seems to me therefore certain that the position in which the Aptychi are found is not that in which they are of use. We must remember that the fossils are remains of *dead* shells, in which all the muscles would be relaxed, and the position in which they occur is that in which they *then* assume; while in life they would be drawn by appropriate muscles into a more transverse position with respect to the aperture, and might possibly serve as a protection to some particular organ when the animal was extruded from its shell—perhaps the nidamental gland, or, it may be, the branchiæ. As to the questions whether the Aptychus is found only in female Ammonites, or whether some of those found in abundance where ammonite shells are not abundant in proportion belonged to naked Cephalopods, we have not sufficient data to decide them.

Aptychi are sometimes calcareous and in two pieces, when they form what has been called *Trigonellites*, one form of which is pretty common in the Yorkshire Lias, and is known as *T. Whitbyensis;* sometimes the corresponding structure is horny, and in one piece, when they are known as *Anaptychi;* and many Ammonites have as yet never yielded any associated structures of this kind, and are judged to be without them. If we seek to discover the classificatory value of these organs, from their comparison with opercula, we are left in some doubt, as there are genera in which these may either be absent or present in the different species (*e.g.*, Mitras, Olivas, and Cones), and others in which it may be horny or calcareous (*e.g.*, Ampullarias and Naticas).

We come next to the form of the aperture. It can only be due to the rarity of specimens preserving complete apertures that this feature, of so great importance in the classification of gastropods, has been so entirely neglected. The commonest form of aperture consists in a simple constriction previous to the termination, a constriction which, like the varices of the *Muricidæ*, leaves its mark on the shell, in the form, in this case, of periodical depression on the side of the whorl. In like manner the ornaments of many other species are simply the relics of former apertures, and by their sigmoidal, biflexed, or concave form enable us to judge of the shape of the former. All ornaments, however, are not due to this; and in this case they have less classificatory importance. The line of termination of the less simple apertures presents three different forms. It may either be prolonged on the ventral (out) side, or on the dorsal (in) side;* or may have two lateral processes, in some instances dilating at the extremity, so as to form a disc supported upon a stalk. The ventral prolongation is probably for the support of the funnel; the dorsal—occurring in those species whose whorls

* This nomenclature is exactly opposite to that of D'Orbigny and other naturalists, who speak of the outside of an Ammonite as its "back;" but a consideration of the position the animal must have occupied in life shows that the present is the proper nomenclature.

are only just in contact—may be for the strengthening of the shell, the mantle spreading over the former whorl; but the object of the lateral processes or auricles is more doubtful. Suess supposed that they were pedicles for the attachment of the muscles, and that those Ammonites which possessed them were partially naked, and could never withdraw wholly into their shell; but this is rendered improbable, because these auricles are variable in the same species; they often co-exist with a long body-chamber, and also with aptychus. If the latter acted as an operculum, the animal could scarcely have been unretractile. No other use has as yet been suggested for them; but it seems very probable that they are in some way connected with reproductive processes. In some of the Ammonites from Solenhofen, both those which present these auricles, and those which have a sigmoidal aperture, are seen curved lines (see Oppel, 'Pal. Mitth.,' pl. 69, and M. Favre's paper), which certainly represent the line of attachment of the mantle to the shell, and these end at the spot where the auricles begin to be developed; the portion, therefore, of the aperture which lies on the dorsal side communicates with the ovaries, which, in the Nautilus, lie behind the line of attachment of the mantle; and thus we are led to the supposition that the auricles will act as a protection to the extruded ova, which may have lain in clusters between them and the last whorl, as they do in the recent Argonaut, in which the enormous body-chamber (constituting the whole shell) needs no such assistance from a prolongation of the shell. It is worth remarking, however, that the possessors of these auricles are chiefly (not exclusively) those whose external edge is ornamented, like the Argonauts', by a double series of knobs, whose office is in the latter case to keep the two expanded arms in contact with the shell. And it may well be that these auricled Ammonites had also a pair of expanding arms, which obtained a certain amount of support from these processes; but on this I could not insist.

The last feature of importance is the length of the body-chamber. Remarkable differences are found in this respect in the whole group, but they are not so noticeable in English jurassic species, which generally have a body-chamber of a length of from two-thirds to a whole whorl. Some Triassic forms, however, have very short chambers; and it must, I think, be acknowledged that, if associated with other characters, this is an important element in classification.

Of these seven elements—the spiral angle and its constancy; the retardation of the inner edge, or amount of involution; the general ornaments; the sutures; the aptychus; the form of the aperture; and the length of the body-chamber—only the first four were made use of until Suess, in 1865 ('Ueber Ammoniten,' Sitz. K. Akad. Wiss. Wien, vol. lii.), inaugurated a new method, by introducing the consideration of the last three, less easily observable, features, and giving names to the separated genera.

It was, perhaps, inevitable that this revision should have come from Germany, as English specimens showing these characters have hitherto been of too great rarity to give materials for the work. I, therefore, think it best here simply to transcribe the table of genera according to the new scheme, as given by M. Favre in the paper alluded to, only premising that the considerations explained above lead me to consider it a great improvement on our former classification.

GENERA OF AMMONITES.

A. Aptychus ABSENT.

Chamber short; appendage ventral	PHYLLOCERAS (Suess). *Triassic to Cretaceous.*
Chamber short; appendage dorsal	LYTOCERAS (Suess). *Triassic to Cretaceous.*
Chamber $1\frac{1}{2}$—2 whorls	ARCESTES (Suess). *Triassic.*
Chamber short; appendage ventral; apertural margin falciform; ornaments argonautiform	TRACHYCERAS (Laube). *Triassic.*

B. Aptychus PRESENT.

I. *Aptychus* undivided.

1. Horny (*anaptychus*).

Chamber 1—$\frac{1}{2}$ whorl; pointed ventral appendage	ARIETITES (Waagen). *Triassic and Liassic.*
Chamber $\frac{2}{3}$—1 whorl; rounded ventral appendage	ÆGOCERAS (Waagen). *Triassic and Liassic.*
Chamber $\frac{1}{2}$—$\frac{2}{3}$ whorl; long ventral appendage	AMALTHEUS (Montf.). *Triassic to Cretaceous.*

2. Calcareous (*sidetes*).

Shell unknown	*Cretaceous.*

II. *Aptychus* divided, calcareous.

1. *Aptychus* externally furrowed.

Aptychus thin; chamber short; apertural margin falciform, with acute ventral appendage ..	HARPOCERAS (Waagen). *Jurassic.*
Aptychus thick; chamber short; apertural margin falciform, rounded ventral appendage ..	OPPELIA (Waagen). *Jurassic and Cretaceous.*
Chamber short; with a groove or swelling near the aperture; margin with auricles and rounded ventral appendage ..	HAPLOCERAS (Zitt.). *Jurassic and Cretaceous.*

2. *Aptychus* thin; granulated externally.

Chamber long; apertural margin simple, or furnished with auricles	STEPHANOCERAS (Waagen). *Jurassic and Cretaceous.*

Chamber long; aperture narrowed by a furrow, simple or furnished with auricles	PERISPHINCTES (Waagen). *Jurassic and Cretaceous.*
Chamber short; aperture simple or furnished with auricles ..	COSMOCERAS (Waagen). *Jurassic and Cretaceous.*

3. *Aptychus* thick, smooth, punctated externally.

? Chamber long; umbilicus large; shell with furrows—ventral appendage nasiform	SIMOCERAS (Zitt.). *Tithonic.*
Chamber short; apertural margin generally simple	ASPIDOCERAS (Zitt.). *M. and U. Jurassic and L. Cretaceous.*

There are two other genera established not included in the above scheme: *Pinacoceras* (Moisis), of the Trias, between *Arcestes* and *Trachyceras;* and *Peltoceras* (Waagen), Jurassic, between *Perisphinctes* and *Aspidoceras.* There are also the uncoiled and irregular genera, *Scaphites*, &c. Another genus was also established by Waagen, *Œkotraustes*, for *Oppelias* that had a bend inwards in the last whorl, as *Scaphites* has a bend outwards, and I think has as much right to be retained as the latter. Many changes will no doubt take place in this arrangement as more attention is drawn to the subject, but our only concern at present is with those sub-genera which occur in our Yorkshire Lias; these are, *Phylloceras*, *Lytoceras*, *Arietites*, *Ægoceras*, *Amaltheus*, *Harpoceras*, *Stephanoceras*, and the characters of these will now be given more in detail.

Phylloceras, *Suess* (*Heterophylli*).

1865. Suess. 'Ueber Ammoniten.' Sitz. K. Akad. Wiss. Wien, lii.

Ex.: *Phylloceras heterophyllum*, Sow. (*Ammonites*).

Shell involute; umbilicus narrow, with fine striæ or smooth; body-chamber two-thirds of the east whorl; apertural edge simple; lobes very complicated, and numerous, generally nine on each side, saddles bladder-shaped; no aptychus found.

Lytoceras, *Suess* (*Fimbriati et Lineati*).

1865. Suess. *loc. cit.*

Ex.: *Lytoceras fimbriatum*, Sow. (*Ammonites*).

Shell discoid; umbilicus large; whorls round, not overlapping, only in contact; surface with fringed ribs, sometimes smooth; body-chamber half a whorl: apertural edge simple, without auricles; ventral side very slightly produced; dorsal side with a lappet lying on the previous whorl; lobes much branched, digitations small and uniform; only two side lobes, and a large dorsal (inside) one covered by the former whorl; no aptychus found.

Arietites, *Waagen* (*Arietes*).

1869. Waagen. 'Die Formenreihe des Ammonites subradiatus.' Benecke's 'Palæont. Beiträge,' Bd. II., Heft 2.

Ex.: *Arietites Bucklandi*, Sow. (*Ammonites*).

Shell keeled; radiately ribbed; body-chamber 1 to 1¼ whorls; apertural edge simple with a pointed ventral prolongation; lobes simple, with a horny anaptychus.

Ægoceras, *Waagen* (*Capricorni*, *maciocephali*, &c.).

1869. Waagen, *loc. cit.*

Ex.: *Ægoceras capricornum*, Schloth (*Ammonites*).

Shell, with generally a wide umbilicus; rounded ventral side, with radiating ribs; body-chamber ⅘ to 1 whorl; apertural edge with a thickened or drawn-in lip, and a ventral prolongation; no auricles; lobes generally complicated; with an anaptychus.

Amaltheus, *Montfort* (*Amathei falciferi*, *pars*, &c.)

1808. Montfort. 'Conchytiologie Systématique,' I. p. 91.
1869. Waagen, *loc. cit.*

Ex.: *Amaltheus margaritatus*, Montfort.

Shell with pretty straight radii, bent forwards near the ventral side, which is keeled or smooth; body-chamber ½ to ⅔ whorl; apertural edge simple, having on the ventral side an incurving spoon-shaped process; lobes not very simple, but broad; with an anaptychus.

Harpoceras, *Waagen* (*Falciferi*, *Disci*, *pars*, &c.).

1869. Waagen, *loc. cit.*

Ex.: *Harpoceras radians*, Rein., sp.

Shell with sickle-shaped sculpture; ventral side keeled or rounded; body-chamber ½ to ⅔ whorl; apertural edge with auricles, or sickle-shaped; ventral process pointed, or round; lobes little denticulated, not bladder-shaped; aptychus more or less furrowed externally.

Stephanoceras, *Waagen* (*Coronarii*, &c.).

1869. Waagen, *loc. cit.*

Ex.: *Stephanoceras commune*, Sow., sp.

Shell ornamented with rings which are broken on the ventral side, no constrictions; body-chamber 1 to 1¼ whorls; apertural edge simple, with a raised lip, a few only with auricles in youth; ventral process rounded; aptychus, thick warty.

The Ammonites of the Yorkshire Lias have always attracted a considerable amount of attention on account of their abundance and variety, and many names have been assigned to them, more

even than they actually required. Young and Bird distinguished 43 species, besides two—*A. heterophyllus* and *A. subcarinatus*, that they described as *Nautili*; of these 15 were adopted from Sowerby's Mineral Conchology, 4, however, being synonymic or wrongly identified and 4 also of their own names must be reckoned as synonymic, leaving 37 known to them, but in many cases obscurely described. To these Phillips added 12, of which 3 were varieties of those already noticed, 2 were non-liassic, 5 were for the first time recognised in Yorkshire, and 2 were new, bringing the total to 44. In 1843 Simpson published a 'Monograph of the Ammonites of the Yorkshire Lias,' without any figures; in this he enumerated 108 species, of which 50 were supposed to be new. Many of his names, however, both original and adopted, were afterwards superseded in 1855 by his 'Fossils of the Yorkshire Lias,' in which 191 names were applied, which included all those that had before been used. Three of these are applied to non-liassic shells by mistake, but I cannot agree with the author in considering all the remainder as sufficiently distinct from each other to deserve a specific name, while some are in my opinion the young of others, and some are described from insufficient material. After all such deductions we find the total number raised to 89, of which 64 go under older names than Simpson's, and 5 are adopted on his authority alone as I have not seen them. In the following year Oppel recognised several of these under their proper names, and added an additional form (*Semanni*); and the third edition of Phillips's 'Geology of Yorkshire' contains two corrections of names, but adds no species. Our additions consist of 20 recognised in Yorkshire for the first time and 4 new species, and we now reckon a total of 113 deserving of a specific name that are known to us, and 6 more that have been already described but which I cannot identify, and I have been unable to see them.

Although for stratigraphical purposes the general name *Ammonites* is retained at present; yet to help forward the transition to the better system I shall describe them under the heads of the smaller genera above defined, altering the termination to agree with the gender, and not putting "sp." after each quotation, because *all* the forms have hitherto been called "Ammonites."

GENUS ÆGOCERAS.

Ægoceras planorbis, *Sowerby*.

1821. 'Min. Conch.' t. 448.
Syn.* 1829. *Erugatus*. Phillips. 'Geol. York.' t. 13, fig. xiii.
1843. Simpson. 'Mon. Am.' and 1855 'Foss. Y. L.' p. 42.

The flattened specimens obtained from the clays of Cliff agree with Sowerby's type, as do those in the Eston gypsum pit,

* Only those references are here given that deal with Yorkshire specimens, or are necessary for the justification of the name.

but the more perfect specimens, which are obtained from blocks of limestones washed up by the sea, and which have long been known under the local name of *A. erugatus*, are a little less involute. Their association with fossils elsewhere unknown in the horizon to which this species gives its name seem to indicate that they belong to slightly later beds. Two varieties are found in Yorkshire and elsewhere (corresponding to the *A. psilonotus lævis* and *A. p. plicatus*, of Quenstedt), one smooth and the other with light bent ribs. Some specimens show the body-chamber to be ¾ a whorl, and the aperture to have a slight constriction behind it and forming a slight ventral process, but no anaptychus has been yet found in them here.

Geological position.—Zone of *A. planorbis*, N. Cliff, Robin Hood's Bay, Eston and E. Coatham pits.

Ægoceras Johnstoni, *Sowerby.*

1824. 'Min. Conch.,' pl. 449, fig. 1.
Syn. 1843. *Belcheri.* Simpson. 'Mon. Am.,' and 'Foss. Y. L.,' p. 43.

This is associated with *Æg. angulatum* at N. Cliff, but also descends to a lower level. The ribs are sometimes more numerous and slender, sometimes fewer and the back almost angular. It also occurs in nodules on the coast and *in situ* at Redcar. It is nearly allied to the ribbed variety of *Æg. planorbis.*

Geological position.—Zone of *A. planorbis*, Cliff, Robin Hood's Bay, Coatham Marsh. Zone of *A. angulatus*, Cliff, Leigh Dam, Scar, Eston Pit.

Ægoceras angulatum, *Schlotheim.*

1820. 'Petrefactenkunde,' p. 70. Quenstedt. 'Jura,' t. 3, figs. 1–2.
1856. Oppel. 'Juraformations,' p. 75.
1875. Phillips, *loc. cit.* 3rd ed. p. 78.
Syn. 1822. *Redcarensis.* Young and Bird. 'Geol. Survey,' p. 258. non. pl. xiv. fig. 10.
1855. Simpson. 'Fossils Y. L.,' p. 100.
" *Æqualis.* Simpson, *loc. cit.* p. 49.
non *anguliferus.* Phillips.

This was first recognised by Young and Bird, but the figure given is erroneous. It was identified by Oppel as belonging to the previously described species of Schlotheim. There are two varieties: (α) most involute, the outer whorl being more than ⅓ the diameter—the common Redcar fossil; (β) less involute, with outer whorl ¼ the diameter, occurring chiefly in the southern area. The largest known is about 3 inches in diameter.

The *A. æqualis* of Simpson is a peculiar form of the latter variety appearing from its matrix to come to slightly higher beds than usual, but it is only a fragment.

The *A. anguliferus* of Phillips, identified by Oppel and Phillips with this species, is from the Middle Lias, and I consider it a variety of *Æg. capricornum.*

The front is elevated, and the numerous strong ribs run to an angle in the middle, where, however, they become less marked and are subordinate to the pseudo-keel, to which they are joined. The ribs are closer together than in *Æg. raricostatum*, and the whorls are more inflated. In another specimen there is a tendency to a tubercle at the turn of the ribs. I have only seen two examples of this in the Leckenby Collection under the name *finitimus*, Bean MS., which I have adopted.

Geological position.—Probably zone of *A. Bucklandi*, Robin Hood's Bay.

Ægoceras (?) viticola, *Dumortier.*

1867. 'Etudes Pal. sur les Dépôts Jurassiques,' Pt. II. pl. xxxi. figs. 9–13.

A single example in the Leckenby Collection. It is a near ally of the last.

Geological position.—Probably zone of *A. Bucklandi* or *A. oxynotus.*

Ægoceras nigrum, *Spec. nov.*

Pl. VI. fig. 6.

Small, compressed, four whorls exposed, centre depressed, last whorl $\frac{3}{11}$ of the diameter, inner whorls $\frac{1}{4}$ concealed, sides nearly flat for the inner two-thirds, then bend at a marked angle towards the front, on which they meet at a little more than a right angle. Shell constantly present, transversely striated, striæ bending forwards on the front, most marked where they meet; diameter $\frac{3}{4}$ inch, thickness $\frac{1}{5}$ inch.

Sutures only seen in the innermost whorls.

This species has a very distinct appearance, differing from *Æg. planorbe* in its angular front and sudden bend on the side. It has, in its present state, a remarkably black colour, which has suggested its trivial name.

Geological position.—Zone of *A. Bucklandi*, Robin Hood's Bay. With *Æg. Birchii* (4 exs.).

Ægoceras Birchii, *Sowerby.*

1820. 'Min. Conch.' pl. 567.
1855. Simpson. 'Fossils Y. L.,' p. 68.
Syn. 1855. *Bispicatus.* Simpson, *loc. cit.* p. 102.

I have not seen *A. bispicatus*, but can see nothing in its description to prevent its being an old *A. Birchii*, which may become a little more involute with age.

Geological position. — Zone of *A. Bucklandi*, Redcar (Tate), Robin Hood's Bay.

Ægoceras Scoresbyi, *Simpson.*

1843. 'Mon. Am.,' and 1855, 'Fossils Y. L.,' p. 69.
Syn. 1867. *Locardi* Dumortier. 'Dép. Jur.,' Pt. II. pl. xxvi. figs. 1–3.

This species may be shortly described as an *Ægoceras Birchii*, in which the whorls are more rounded, and the ribs are so strong that they quite obscure the tubercles, especially the inner ones. Indeed, Dumortier says of his *A. Locardi*, that it has only one range; but his figure shows a rising towards the inside of each rib, which proves it only to be an extreme form of this.

Geological position.—Lower Lias, Robin Hood's Bay. Simpson (1 ex. in Whitby Museum).

Ægoceras planicosta, *Sowerby.*

1814. 'Min. Conch.,' pl. lxxiii.
1855. Simpson. 'Fossils Y. L.,' p. 45.
Syn. 1830. *Ziphus.* Zieten. 'Verst. Würtembergs,' tab. v. fig. 2.
1843. *Mammillatus.* Simpson. 'Mon. Am.,' and 1855, 'Fossils of Yorkshire Lias,' p. 67.
1855. *Siphuncularis.* Simpson, *loc. cit.* p. 88.
„ *Convolutus.* Simpson, *loc. cit.* p. 43.

This is most commonly met with in the typical form, but in some the outer whorls develop great tubercles while the inner whorls are of the typical form. This feature sets in sooner in some and later in others. When thus developed we have the *A. ziphus* of Zieten, and the *A. mammillatus* of Simpson. The *A. siphuncularis* of the latter author is merely one in which the matrix has only been consolidated round the circumference, forming a kind of surrounding cord. His *A. convolutus* is small and immature.

Geological position.—Zone of *A. oxynotus* (towards the base), Robin Hood's Bay.

Ægoceras gagateum, *Young and Bird.*

Pl. VI., fig. 8.

1822, 8. 'Geological Survey,' pl. xii. fig. 7.
1845. Simpson. 'Fossils Y. L.,' p. 45.
Syn. 1842. *Turrilites Coynarti.* D'Orbigny. 'Terr. Jur.' pl. xlii. figs. 4–6.
1855. *Neglectus, integricostatus, cereus, illatus?* Simpson. 'Fossils Y. L.,' pp. 45–7, 39.

Neither the description nor figure of Young and Bird give a good idea of this shell, though their name for it derived from "the smaller showing their prominent ribs like rows of jet beads," is very speaking to a local collector. It is intermediate in form, as in time, between *Æg. planicosta* and *Æg. capricornum*, but it is cut off as sharply from either as its range is limited. The ribs are very prominent, and the inner edge of the whorls are remarkably elevated, almost overhanging. It is sometimes a little one-sided, so that it may be the *Turrilites Coynarti* of

D'Orbigny. It does not vary much, and the synonyms belong to nothing remarkable.

Geological position.—Zone of *A. oxynotus*, of which it is highly characteristic. Robin Hood's Bay, Warter and Market Weighton.

Ægoceras sagittarium, *Spec. nov.*

Pl. VII., fig. 2.

Syn. *Jamesoni* (pars). Sowerby and Simpson.

This species has long been confounded with *Æg. Jamesoni*, to which it is somewhat similar, but it is really different and comes from a different horizon. Specimens are generally only outer whorls, but the description and figure are taken from a specimen in the Cambridge Museum, which shows the inner whorls. Whorls 5, compressed, but uniformly rounded; last whorl $\frac{1}{3}$ diameter, inner whorls $\frac{1}{4}$ concealed; radii straight, moderately elevated and rounded, 23 in a diameter of 3 inches, meeting on the front with a slight elevation running longitudinally from point to point; diameter 2·6 inches; sutures like those of the genus *Arietites*. This differs from *Æg. Jamesoni* in the oval shape of whorls, the straightness of the ribs and their union by a line along the front.

Geological position.—Zone of *A. oxynotus* (base), Robin Hood's Bay.

Ægoceras (?) raricostatum, *Zieten.*

	1830.	'Petref. Würtembergs,' pl. xiii. fig. 4.
Syn ?	1855.	*Exortus.* Simpson. 'Fossils Y. L.,' p. 44.

The young forms are somewhat like the young of the next, but differ by a slight appearance of a keel. I have not seen the *A. exortus* of Simpson, but its description would lead to its identification with this.

Geological position.—Zone of *A. oxynotus* (top), Robin Hood's Bay, in hard nodules.

Ægoceras obsoletum, *Simpson.*

Pl. VII., fig. 1, *a*, *b*.

	1843.	'Mon. Am.,' and 1855, 'Fossils Y. L.' p. 59.
Syn (adult).	1849.	*Armatus densinodus.* 'Cephalopoden,' tab. iv. fig. 18.
	1856.	*Densinodus.* Oppel. 'Juraformations,' p. 89.
Syn (jun.).	1855.	*Vitreus, cereus.* Simpson, *loc. cit.* p. 46, 47.
	1856.	*Subplanicosta.* Oppel, *loc. cit.* p. 89.

The name *A. densinodus* has been used for this species in Part I., but Simpson's name has priority. The shell is compressed, the whorls flat, five of them exposed, uncovered; the last whorl $\frac{1}{4}$ diameter; numerous straight ribs, with accompanying striæ; there is a very slight knob half-way across the radius,

and a stronger one at the turn on to the front; these latter form a very regular series, like dewdrops surrounding each whorl; front narrow, with a very faint mid-line; diameter 4 in.

In the young state, specimens of which accompany the adults in abundance, or may be picked out of their centre, the ribs are much sharper, and are without tubercles, and sometimes pass over the front. It then looks more like *A. planicosta* than its own adult form, and has therefore been called *A. subplanicosta* by Oppel.

Geological position.—Zone of *A. oxynotus.* In almost every nodule of a certain band in the upper part of the zone at Robin Hood's Bay. Londesborough.

Ægoceras armatum, *Sowerby.*

1815. 'Min. Con.,' t. 95.
1855. Simpson. 'Fossils Y. L.,' p. 64 (non Young and Bird).
Syn. (adult)? 1822, 8. *Hastatus.* Young and Bird, *loc. cit.* pl. xiv. fig. 2.
1855. *Miles.* Simpson, *loc. cit.* p. 65.
(Sen.) 1855. *Hastatus, spicatus, subtriangularis, armiger, Hamiltoni.* Simpson, *loc. cit.* p. 64–67.
(Jun.) 1855. *Owenensis, tubellus* (pars). Simpson, *loc. cit.* pp. 64, 42.

The confusion that has existed about this species is remarkable. Some portion of Sowerby's description seems to have puzzled the local palæontologists. His type-specimen is one of many which may be found even now just north of the village of Robin Hood's Bay, where, I am told, they have been occasionally obtainable by basketfuls. It is smooth when young, in which state it has been noticed by Simpson, who remarks upon his species that they have tubercles towards the end of their body-whorl. Sowerby's form was from middle life; and when the species grows old, its tremendous spines are not very constant in form or position, whence it has obtained various names; but none of these so-called species are known young, except as the ordinary *Æg. armatum.* Young and Bird's *A. hastatus* is drawn more involute than *Æg. armatum* is, and may belong to one of the other armed forms.

Geological position.—Sub-zone of *A. armatus* (characteristic), Robin Hood's Bay, Warter, High Stones Redcar.

Besides *Æg. armatum*, in which the ornamentation is regular, and of which the identification is always easy, there is a series of Ammonites associated with it, whose chief character is irregularity of ornament. Forms of this series have been figured by Dumortier under the names of *Morogensis* and *submuticus*, but they cannot be satisfactorily identified with Yorkshire specimens, which thus remain peculiar. The young state of these shells is like the *A. Grenouillouxi* of D'Orbigny. Of these and their young many species have been made by Simpson; but after examination of a good number, *three* names appear to be sufficient: *aculeatum*, *validum*, *sociale*.

Ægoceras aculeatum, *Simpson.*

Plate VII., fig. 4.

1843. 'Mon. Am.' and 1855, 'Fossils Y. L.,' p. 66.
Syn. 1843. *Decussatus.* Simpson. 'Mon. Am.'
1855. *Decussatus, retusus,* and *mutatus?* Simpson. 'Fossils Y. L.' p. 62, 63.
Syn. (jun.). 1843. *Marshallani.* Simpson. 'Mon. Am.,' and 1855, *loc. cit.* p. 62.

This has a somewhat similar form to *Æg. armatum,* but is more involute. In youth it is umbilicate, and resembles *A. Grenouillouxi* (D'Orb.), each radius ending in a small knob, and the front being depressed. This forms the *A. Marshallani* of Simpson. As it grows older, however, the whorls become rounded, the ribs become irregular and more numerous, and every now and then, but not at equal intervals, the radii are more elevated, or are provided with comparatively small, sharp tubercles, or both. The radii are more marked over the front, where they are finely fimbriated, than on the sides. The sutures are of the same kind as in *Æg. armatum,* but more complicated, and their details distinguish it from *Æg. sociale.* It varies in the number and regularity of the tubercles, and in the inflation of the whorls, whence the synonyms. The *A. mutatus* of Simpson I have not seen, but I think, by its description, it must belong here.

Geological position.—Sub-zone of *A. armatus,* Robin Hood's Bay.

Ægoceras validum, *Simpson.*

Pl. VII. fig. 3.

1855. 'Fossils, Y. L.,' p. 62.
Syn. 1822, 8. *Armatus.* Young and Bird, pl. xiv. fig. 3.
1855. *Nativus.* Simpson, *loc. cit.* pl. lxviii.

This has the same general form as *Æg. aculeatum,* but is more robust, the last whorl being broader than high. The radii are far more regular and straight, but are ill-defined, consisting rather of transverse swellings within the large knobs; on the front the ribs start from these knobs and separate into pairs or triplets, to unite again on the other side; they are very coarse. In the outer whorls the radii become less regular.

The *A. nativus* of Simpson is a step from this to *Æg. aculeatum,* as it has the ornaments more irregular.

Geological position. — Sub-zone of *A. armatus,* Robin Hood's Bay (5 exs.).

Ægoceras sociale, *Simpson.*

Pl. VII. fig. 6.

1855. 'Fossils Y. L.,' p. 39.
Syn. 1843. *Plicatilis.* Simpson. 'Mon. Am.' (non Sowerby).
1855. *Involutus.* Simpson. 'Fossils Y. L.,' p. 39.

The general build of this species is that of *Æg. aculeatum,* but

it has no tubercles in the adult. The radii are equal, and pass undivided over the front, where they are very regular and obscurely fimbriated. The inner whorls are about ⅓ concealed. The sutures are like those of *Æg. aculeatum*, but the chambers are longer.

It is possible the Hauer's species. *A. Baggazoni* ('Ueber die Ammoniten aus Medolo,' 1861. figs. 16, 17), may represent this form abroad, but the whorls of that species are more inclined to be transverse.

Geological position.—Sub-zone of *A. armatus*, Robin Hood's Bay (5 exs.).

Ægoceras tubellum, *Simpson.*

Pl. V., fig. 7.

1855. 'Fossils Y. L.,' p. 42 (pars).

It is with great doubt that I admit this species, it is so like the young of *Æg. armatum*, and is associated in the same beds with it at Robin Hood's Bay; but the more rapidly-enlarging whorls and trumpet-shaped mouth may serve to distinguish it. Its aperture is elliptical, and there are signs of sigmoidal radii. Those which are quoted by Simpson as showing signs of tubercles I exclude, and associate with *Æg. armatum.*

Geological position. — Sub-zone of *A. armatus* (base), Robin Hood's Bay (5 exs.).

Ægoceras Taylori, *Sowerby.*

1826. 'Min. Con.,' pl. 514.
Syn. 1843. *Cornutus.* Simpson. 'Mon. Am.'
1844. *Lamellosus.* D'Orbigny. 'Terr. Jur.,' tab. 84.
1855. *Cornutus, quadricornutus.* Simpson. 'Fossils Y. L.,' p. 71.

The two varieties of this rare shell which Quenstedt indicates by the names *nodosus* and *costatus* are very dissimilar, and their scarcity in Yorkshire would have prevented their being united; but as they occur together, and the most tuberculated form is seen itself to vary in the number of tubercles, as noticed by Simpson and marked by his two names, we are not in a position to overrule the dictum of foreign geologists, that they must be considered one species. We may, however, designate the less tuberculated form as var. *lamellosum*, the presence of which does not seem to have been noticed, or it would certainly have received a name.

Geological position.—Sub-zone of *A. armatus*, Robin Hood's Bay (6 exs.).

Ægoceras Jamesoni, *Sowerby.*

1827. 'Min. Con.,' tab. 555, fig. 1 (non Simpson).

This species, with quadrangular whorls and undulating ribs passing over the front, though giving its name to a zone, is by

no means so common as might hence be expected; and it is only in the area north of Whitby that specimens can be satisfactorily identified as belonging to it. Those from Robin Hood's Bay and elsewhere so called are mostly a different species, which I have described as *Æg. sagittarium*, and which belongs to a different zone. In this area the allied *Æg. brevispinum* takes its place as a characteristic fossil.

Geological position.—Zone of *A. Jamesoni* (characteristic), Rockcliff, Huntcliff, Coatham Scars, Normanby, Easby, Robin Hood's Bay.

Ægoceras brevispinum, *Sowerby*.

1827. 'Min. Con.' pl. 556, fig. 1.
1855. Simpson. 'Fossils Y. L.,' p. 69.
Syn. 1855. *Aureus, tenuispina?* Simpson, *loc. cit.*

The *A. aureus* of Simpson I regard as the young of this. His *A. tenuispina* I have not seen, but judge, from its description, that it is a well-preserved young example of the same.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Normanby, Osborne Rush Pit, Upsall.

Ægoceras Regnardi, *D'Orbigny*.

1844. 'Terr. Jur.,' tab. 72.
Syn. 1855. *Ignotus.* Simpson. 'Fossils Y. L.,' p. 61.

This I distinguish from *Æg. Jamesoni*, with which Oppel unites it, by its more numerous ribs and their great tendency to put on tubercles at the turn on to the front.

Geological position.—Zone of *A. Jamesoni*, Huntcliff (3 fragments).

Ægoceras Heberti, *Oppel*.

1856. 'Juraformations,' p. 158.
Syn. 1844. *Brevispinum.* D'Orbigny. 'Terr. Jur.,' pl. lxxix. (non Sowerby).

Oppel gave this name to the shell figured by D'Orbigny as above, which differs from *Æg. brevispinum* in the more rapid increase of the whorls and the feebleness of the ribs. The only example I have seen is in the York Museum, and agrees perfectly with D'Orbigny's figure.

Geological position.—Unknown, but probably sub-zone of *A. armatus*.

Ægoceras Grenouillouxi, *D'Orbigny*.

1844. 'Terr. Jur.,'pl. xcvi.

The proof that this is a true species as distinct from the young of *Æg. aculeatum*, which much resembles it, is that its ribs and exterior tubercles are more regular and the sutures are different. It also is generally more transverse.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay (4 exs.).

Ægoceras striatum, *Reinecke.*

1818. 'Nautilos et Argonautas,' figs. 65, 66.
1822, 8. *Heptangularis.* Young and Bird, *loc. cit.* pl. xiv. fig. 1.
Syn. 1844. *Henleyi.* D'Orbigny. 'Terr. Jur.,' tab. lxxxiii. (non Sowerby).
1855. „ Simpson. 'Fossils Y. L.,' p. 70.

In the true *Æg. striatum* the whorls increase rapidly in every dimension, leaving a narrow and deep umbilicus, in which less than half the inner whorls are visible. It must not be confounded, as has generally been done on account of the similarity of ornaments, with *Æg. Henleyi*, which is more evolute and has a peculiar history. The distinctness of the two species was seen by Young and Bird, but has since been lost sight of by several authors.

Geological position.—Zone of *A. Jamesoni* (rare, at the top), Robin Hood's Bay, Rockcliff, Huntcliff.

Ægoceras Henleyi, *Sowerby.*

1817. 'Min. Con.,' pl. clxxii.
Syn. 1822, 8. *Heterogenes.* Young and Bird, *loc. cit.*, pl. xiv. fig. 7.
1844. *Hybrida.* D'Orbigny. 'Terr. Jur.,' pl. lxxxv.
1855. *Heterogenes.* Simpson, *loc. cit.* p. 69.

Sowerby's figure represents fragment of the outer whorl only, which is similar to that of *Æg. striatum*, and has therefore been generally confounded with it. But it is more evolute and less tumid. In this species the young form is very similar to that of *Æg. capricornum*, which has led to the idea that this is only the adult form of that species, but this latter grows to as large a size as any *Æg. Henleyi* without showing any of its peculiar ornaments, and two species may certainly be similar when young. Its change is, however, certainly very remarkable.

Geological position. — Zone of *A. capricornus*, Huntcliff, Robin Hood's Bay.

Ægoceras Bechei, *Sowerby.*

1821. 'Min. Conch.,' pl. cclxxx.
1855. Simpson. 'Fossils Y. L.' p. 70.

Geological position.—Probably zone of *A. Jamesoni* (3 exs.).

Ægoceras capricornum, *Schlotheim.*

1820. 'Petrefactenkunde,' p. 71.
Syn. 1822, 8. *Maculatus.* Young and Bird, *loc. cit.* pl. xiv. fig. 9.
1829, 35. „ Phillips. 'Geol. of Yorkshire,' pl. xiii. fig. 11.
„ *Arcigerens.* Phillips, *loc. cit.* pl. xiii. fig. 9.
1855. *Maculatus, luridus, figulinus, arcigerens?* Simpson. 'Fossils Y. L.,' pp. 46, 78.
? 1827. *Lataecosta.* Sowerby. 'Min. Con.' pl. 556, fig. 2.

This is a rather variable species in respect to the strength of

its ribs, which in some grow to an enormous size, so as to double the section of the whorl taken through them, and pass quite straight over the front; in others they are depressed on the front and grow rather oblique. This form when adult is, I think, the *A. latæcosta* of Sowerby. A specimen in my collection, 4 inches in diameter, agrees well with his figure, and is certainly the adult of *Æg. capricornum.*

The figure of Phillips's *A. arcigerens* best represents this species, but as he classes it with those that have an angular deflection on the front, he may mean the next, as Simpson appears to have thought. The *A. luridus* of the latter author is a variety slightly more involute and with more slanting ribs.

Geological position.—These are generally found in smooth, round nodules, which the expert can predict to have a specimen in before opening them, but they also occur in the shell and oyster beds of the zone of which the species is characteristic, Hummersea, Staithes, Huntcliff, Robin Hood's Bay, Coatham Scars, Belman Cutting, Guisborough.

Ægoceras defossum, *Simpson.*

Pl. VIII., fig. 9.

1855. 'Fossils Y. L.,' p. 48.
Syn. 1829. *Anguliferus.* Phillips, *loc. cit.* pl. xiii. fig. 9.
1855. *Omissus.* Simpson, *loc. cit.* p. 47.

This species has much resemblance to *Æg. capricornum*, and some varieties of the latter approach it, but it may be easily distinguished from its earliest stage. Its ribs are sharper, more numerous, almost, but not quite, tuberculous at the turn on to the front, which is perpendicular to the side, they there bend sharply forwards or become obsolete, but there is sometimes a slight rising where they meet; aperture quadrate.

This is remarkable for its resemblance on the side to *Amatheus spinatus.* It is usually known of small size (½ to 1½ inch). The specimen figured seems to be fairly adult, without making any approach to *Æg. capricornum.*

Geological position.—Zone of *A. capricornus*, Staithes, Hautcliff, Robin Hood's Bay.

Ægoceras diversum, *Simpson.*

Pl. VIII., fig. 3.

1843. 'Mon. Am.,' and 1855. *loc. cit.* p. 45.

This is nearly allied to *Æg. capricornum* and also to *Æg. gagateum.* It is evolute, narrow-whorled, with far-separated, strong radii, which are slightly twisted; each ends in a strong knob or point on the outside, and goes straight across the front without growing weaker, making the surface of the front as

undulating as the side. The inside of each radius is also slightly elevated.

Oppel's *Am. Zitteli* ('Pal. Mitth.,' Pl. XLII., fig. 2) may be the young of this.

Geological position.—Probably zone of *A. capricornus* (with *Pecten substriatus*) (2 exs.).

Ægoceras sinuatum, *Simpson.*

1855, *loc. cit.* p. 62.

A specimen in the Whitby Museum agrees well with the description, and I cannot identify it with any other form. The following is his description :—" Volutions exposed, outer whorl ⅓ diameter, sides convex ; radii obtuse, separated by rather wide concave spaces, commence on the inner margin, slightly incline towards the aperture and then in the opposite direction, form a row of tubercles on the outer margin, nearly obsolete on the back, aperture ovate or sub-quadrate, diam. 4½ inches. A fragment L. L." (1 ex.).

It is some proof of the value of these new genera, that they enable us to note the following fact of distribution, viz. that the *Ægocerata* do not last beyond the zone of *A. capricornus.*

GENUS ARIETITES.

Arietites Bucklandi, *Sowerby.*

Pl. V. fig. 2.

1816. 'Min Con.' pl. cxxx. (Non Phillips. Non Simpson.)

There seems to have been some confusion about this characteristic, though rare, shell in Yorkshire. It is not the same as *A. bisulcatus*, as some authors have supposed, as it possesses no tubercles, and the transverse section of the whole, though quadrangular, is far more rounded. The shell called *A. Bucklandi*, by Simpson, must be either *A. obtusus* or *A. Turneri*, as he says the whorl is one-third the diameter. Phillips' *A. Bucklandi* (jun.) is an *A. Sauzeanus*. The true shell, whose ribs are moderately separate (34 to a whorl) and much curved, is only found, to our knowledge, at Redcar, where it is not common, but grows to a diameter of 8 to 10 inches.

Geological position.—In the limestones of the series to which it gives its name, Redcar.

Arietites bisulcatus, *Bruguière.*

1789. 'Encyclop. Méthodique,' Vers. i. p. 39.
1842. D'Orbigny. 'Terr. Jur.,' pl. xliii.
Syn. 1855. *Valid infractus.* Simpson. 'Fossils Y. L.,' p. 95.

I keep this name for those forms that present a square front, almost transverse, with straight ribs tuberculated outside.

Geological position.—Sub-zone of *A. armatus*, Robin Hood's Bay.

Arietites caprotinus, *D'Orbigny.*

1844. 'Terr. Jur.,' pl. lxiv. figs. 1, 2.

This form is distinguished from the former species, to which it is closely allied, by the straightness of its ribs, which are comparatively wide apart, and rise highest near the outside.

Geological position.—Zone of *A. oxynotus*, Peak (1 ex.).

Arietites ophioides, *D'Orbigny.*

1844. 'Terr. Jur.,' pl. lxiv. figs. 1, 2.

Some specimens in the Leckenby Collection agree in every respect with D'Orbigny's figure and description, but I have a suspicion they are only the young of some other, not of *A. caprotinus*, but possibly *A. spiratissimus*, but I cannot as yet prove this.

Geological position.—Probably zone of *A. oxynotus*, Robin Hood's Bay (5 exs.).

Arietites spinaries, *Quenstedt.*

1858. 'Der Jura,' tab. vii. fig. 4.

This is very closely allied to *A. obesulus*, and its radii are similarly knobbed, but it differs in having the furrows nearly obsolete; the sides are flat and the ribs irregular and bend somewhat backwards.

Geological position.—Zone of *A. Bucklandi*, Robin Hood's Bay (fragments; one good specimen in York Museum).

Arietites rotiformis, *Sowerby.*

1824. 'Min. Con.,' pl. 453.
1855. Simpson. 'Fossils Y. L.,' p. 93 (? pars).

A fine specimen of this species, which differs from *A. bisulcatus* in having narrower whorls, and from *A. multicostatus* in having tubercles on the outer side, in the Leckenby Collection is the authority for inserting it in the list.

Geological position.—Probably zone of *A. Bucklandi* (1 ex.).

Arietites Turneri, *Sowerby.*

1827. 'Min. Con.,' tab. 452, fig. 1.
1829, 35, 75. Phillips. 'Geol. Yorks.' pl. xiv. fig. 14.
1855. Simpson. 'Fossils Y. L.,' p. 95.
Syn. 1855. *Bucklandi* (pars). Simpson, *loc. cit.* p. 95.

With this species are identified some of the very large

Ammonites found on the lowest scars at Robin Hood's Bay. In extreme age they are not easily distinguished from *A. stellaris*; in the latter the whorls grow narrower, in this broader.

Geological position.—Zone of *A. Bucklandi* (upper part). Redcar, Robin Hood's Bay.

Arietites sinemuriensis, *D'Orbigny.*

1844. 'Terr. Jur.' pl. xcv. figs. 1–3.

Similar to *A. bisulcatus*, but with the ribs joining towards the outside, by cross bars.

Geological position.—Zone of *A. Bucklandi*, Marske.

Arietites stellaris, *Sowerby.*

1815. 'Min. Con.,' pl. xciii.
Syn. 1855. *Bucklandi* (pars). Simpson. 'Fossils Y. L.,' p. 97.

This has generally been confounded in Yorkshire, when full grown, with *A. Bucklandi*, and with *A. obtusus* in youth. The former, however, is a very different shell with narrower whorls, and more curved radii. Good examples are not common; they range from ½ inch to a foot in diameter.

Geological position.—Zone of *A. oxynatus* (base), Robin Hood's Bay, Marske (boulders).

Arietites obtusus, *Sowerby.*

1816. 'Min. Con.,' pl. cxlvii.
1855. Simpson. 'Fossils Y. L.,' p. 92.
Syn. 1849. *Cornuoides.* Brown. 'Fossil Conchol.' pl. v. fig. 8.

This may be taken as the final step of *Arietites* towards *Ægoceras* in one direction, the similarity between it and *Æg. sagittarium* being great.

Geological position.—Zone of *A. oxynotus.* Common at Robin Hood's Bay at the base of the series, and not growing to a large size.

Arietites Scipionanus, *D'Orbigny.*

Pl. V., fig. 3.

1842. 'Terr. Jur.' pl. li. figs. 7 and 8.
Syn. 1843. *Personatus.* Simpson. 'Mon. Am.,' and 1855, 'Fossils Y. L.,' p. 38.

A very distinct form, though variable. In youth it is an inflated, almost involute shell, with only the remotest indication of the future growth of a keel, and with a few irregular swellings to denote its future ribs. It varies in the size at which it puts on its proper ornaments, the one Simpson described being 1¼ inch; in all, however, sooner or later, the keel

becomes elevated and acute, forming a triangular front; the sides become flat, with well-marked ribs, running generally straight with an inclination backwards, but often bifurcate and irregular, ending in a small well-defined tubercle, at the base of the triangular front, which is marked with finer lines running forward, often nearly obsolete. The ribs are often prominent also on the inside of the whorl. The outer whorl in middle age is ¼th of the diameter, and the inner whorls are ⅓rd concealed (as far as the tubercles). The shell is finely striated transversely. Specimens known vary from $\frac{1}{32}$nd to 2 inches in diameter.

One variety has its sides more greatly rounded, and has distinct furrows on the front, though shallow ones: the front is thus not triangular, and we have a passage from between this and the next species.

Geological position.—Zone of *A. Bucklandi* (upper part), Marske, Redcar. Not found *in situ* at Robin Hood's Bay, but in blocks associated with *Lima pectinoides*, *Lucina limbata*, *Dentalium etalense*, *Cerithium etalense*, thus indicating the horizon.

Arietites Sauzeanus, *D'Orbigny.*

1844. 'Terr. Jur.,' pl. xcv. figs. 4, 5.
Syn. 1843. *Resupinatus.* Simpson. 'Mon. Am.'
1855. *Resupinatus*, *transformatus.* Simpson. 'Fossils Y. L.,' pp. 43, 91.

A species of moderate size, very easily distinguished by its broad square front, with only the smallest semblance of a keel. The ribs are well marked and run nearly straight, with a more or less marked tendency to bend backwards (*resupinatus*), and end in a tubercle on the outside, where the shell is widest. The young have much resemblance to those of *A. Scipionanus*, and the adults to *Amatheus spinatus.*

Although the name *resupinatus* was earliest applied to specimens of this species, it would be doubtful policy to disturb D'Orbigny's well-known name.

Geological position. — Zone of *A. Bucklandi*, Redcar, Marske, Robin Hood's Bay, Millington.

Arietites semicostatus, *Young and Bird.*

Pl. VI., fig. 4*a* (upper).

1822, 8. 'Geol. Survey,' pl. xii. fig. 10.
1855. Simpson. 'Fossils Y. L.,' p. 93.
Syn. 1856. *Geometricus.* Oppel. 'Juraform.,' p. 79 (non Phillips).
1855. *Multanfractus.* Simpson, *loc. cit.* p. 95.

Young and Bird's figure of this shell is quite deceptive and the description incomplete. Nevertheless, Simpson has well described it and it has long been known. It is a very common form, occurring in masses of hundreds in *Bucklandi* limestone,

and there are numerous specimens of outer whorls in the *oxynotus*-beds which have been called by Oppel *A. geometricus*. No doubt extreme forms look very different, some *semicostati* being inflated in the whorls and the ribs curved, and some *geometrici* being flat and the ribs straight. Nevertheless the passages between them prevent me at present from recognising their distinctness, the only similar one which can always be separated being that next described.

Geological position.—Zone of *A. Bucklandi*, Robin Hood's Bay, Redcar, Marske, Nunthorpe, Ellerbeck. Zone of *A. oxynotus*, Robin Hood's Bay.

Arietites Bodleyi, *Buckman.*

1845. 'Geol. Chelt.' pl. ii. fig. 7.
Syn. 1856. *Hartmanni.* Oppel. 'Juraform,' p. 79.
1843. *Kridion.* D'Orbigny. 'Terr. Jur.' pl. li. figs. 1 and 2.
1855. *Acuticarinatus.* Simpson. 'Foss. Y. L.' p. 94.

This differs from the last in little else than in having no furrows on either side of the keel, which stands out sharply, and in seldom having the inner whorls smooth; the ribs vary as to straightness and number; the breadth of the whorl is also variable.

The Ammonites included under these two names are very variable, and many species might be and have been made out of them, but it seems better not to give more than *two* names to the series.

Geological position.—Zone of *A. Bucklandi*, Redcar, Robin Hood's Bay.

Arietites difformis, *Emmrich.*

Pl. VI., fig. 3 *a*, *b*.

1853. 'Jahr. der K. K. Geol. Reich.' vol. iv. p. 783.
1856. Hauer, 'Ceph. aus d. Lias,' t. vii. figs. 11–14.

It seems rather doubtful if this ought to be separated from the last, but it exhibits an extreme form as to the broadness of whorl, here $\frac{1}{3}$ diameter, and number of ribs; the sides are very flat, and the keel, without furrows, is very prominent, and the whole shell has a peculiar appearance, the ribs being rather curved, almost becoming knobbed outside; shell striated; inner whorls smooth.

Some young smooth ammonites, with sharp backs, may possibly be the young of this— they are probably identical with *A. jejunus* of Dumortier.

Geological position.—Zone of *A. Bucklandi*, Redcar and Robin Hood's Bay.

There are other forms similar to these in their characters, one apparently the same as that called *A. hierlatzicus* by Hauer, l. c., tab. VII., figs. 4—6, and another, *A. ceras*, Giebel, but I

think it unadvisable on present information to insert them in the list.

Arietites Collenoti, *D'Orbigny*.

1844. 'Terr. Jur.' pl. xcv. figs. 6-9.
Syn. 1855. *Denotatus, tenellus.* Simpson. 'Foss. Y. L.' pp. 76, 97.

Usual size, 1 to 2 inches, but grows to a diameter of 6 inches, when it is the *A. denotatus* of Simpson. There can be but little doubt that this is the shell described by D'Orbigny, and, if so, it is not the young of *A. Guibalianus*, as Oppel supposes. It belongs to a family with strongly-marked separated keels, for which, perhaps, two names are sufficient—this and the following—*impendens* (Y. and B.). They are highly characteristic of the middle portion of the *oxynotus*-zone. It is closely allied to *A. oxynotus*, to which it almost passes, but its affinities are not so much with it as with *A. impendens*, on account of its sharply-marked keel, and more abrupt inner edge. A fine specimen in the York Museum shows its character when full grown (5 in. diam); its inner edge is then obliquely truncate; its outer whorl smoother than the inner.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay.

Arietites impendens, *Young and Bird*.

Pl. VI., fig. 7.

1822, 8. 'Geol. Surv.' p. 266.
1843. Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 98.
Syn. 1845. *Fowleri.* Buckman. 'Geol. of Chelt.' pl. xii. fig. 7.
1855. *Radiatus.* Simpson. 'Foss. Y. L.' p. 88.

This differs from the last in its strong ribs, and generally overhanging inner edge. The first of these characters it loses by age, but not the second. However, there are some specimens which do not exhibit the overhanging edge at all, when they are exactly *A. Fowleri* of Buckman, but it appears not sufficient to separate them. The *radiatus* of Simpson is the young of this species. This is very nearly allied to *A. aballoensis* of D'Orbigny, figured by Dumortier, 'Dép. Jur.,' Part II., Pl. XXVII., except for the separation of the keel by furrows.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay.

Arietites (?) Macdonnelli, *Portlock*.

Pl. V., fig. 8.

1843. 'Geol. Rep. of Londonderry,' pl. xxix. A. fig. 12.

Very much compressed; whorls numerous, compressed, ½ concealed; outer whorl ½ the diameter, gradually declining to a sharp keel; aperture sagittate. The inner whorls have numerous sharp ribs, slightly sigmoid, highest outside. The front

in this stage is flat, and without keel. In the adult the ribs become obsolete, and the whorls become nearly smooth, except for a fine striation; and a slight furrow at last arises on either side of the keel.

There could not be a more complete correspondence than between the specimens from Yorkshire and the species described by Portlock, but I can find no certain synonyms.

Geological position.—Sub-zone of *A. armatus*, Robin Hood's Bay and Warter, at which latter place it is especially abundant.

This is the most recent species of the genus Arietites, and doubtfully belongs to it, forming a passage to the *Harpocerata*.

GENUS AMALTHEUS.

Amaltheus oxynotus, *Quenstedt.*

1843. 'Flotzgebirge Würtembergs,' p. 161.
1849. Quenstedt. 'Cephalopoden,' pl. v. fig. 11.
1860. Wright. 'Quart. Jour. Geol. Soc.' vol. xvi. p. 407.
Syn. 1843. *Polyphyllus, Robinsoni, Buckii.* Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' pp. 81, 83, 84.
1845. *Cultellus.* Buckman. 'Geol. Chelt.' pl. xii. fig. 5.
1855. *Dejectus.* Simpson, *loc. cit.* p. 85.

This characteristic species grows more involute and less radiated with age; its youth has thus been noted as a different species (*Buckii, dejectus*). At this stage also it proves its generic position by being crenulate, as seen in *A. Buckii.* It often has more or less marked constrictions, as in *A. Robinsoni.*

Geological position.—Zone of *A. oxynotus* (chiefly the upper part). Robin Hood's Bay and High Stones, Redcar.

Amaltheus Simpsoni, *Beau MS. in Simpson.*

Pl. VIII., fig. 4.

1843. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 79.
Syn. 1843. *Flavus, limatus.* Simpson. 'Mon. Am.' and 1855, *loc. cit.* p. 86.

This species is distinguished from *A. oxynotus* by its swollen whorls, which are widest towards the inner third, and thence gradually decline, becoming almost concave before reaching the keel. It always retains the shell, and has no radii, but is covered with delicate striæ, which sub-crenulate the keel. Its sutures are simpler than those of *A. oxynotus.* These small differences are remarkably constant, and prove it really distinct. Its size also is generally greater, reaching to 8 inches in diameter.

It does not appear to have been noticed out of Yorkshire.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay.

Amaltheus trivialis, *Simpson*.

Pl. V., fig. 6, *a*, *b*, *c*, *d*.

1843. Monograph of Ammonites.
Syn. 1849. *Polymorphus*. Quenstedt. 'Cephalopoden,' t. iv. figs. 9–13.
1843. *Rutilans*, *Ripleyi*. Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' pp. 42–44.

Small (½ to 1 in.), very compressed, with flattened sides, meeting at an angle on the front; ribs irregular; different in the several varieties; bend towards the aperture on the front, where they meet at an obtuse angle; outer whorl ⅖ diameter; inner whorls ⅓ concealed.

Quenstedt forms 5 varieties of this shell, of which we have all but the first—*quadratus*.

Lineatus (fig. 6*b*), in which the radii are very fine; moderately common.

Costatus (fig. 6*d*), in which they are very coarse, but regular; not so common.

Interruptus (fig. 6*c*), where they are wider apart still, and, being broad, look rather like bands; rare.

Mixtus (fig. 6*a*), where the ribs change character and are irregular; commonest of all.

This species is very characteristic of the lower part of the *Jamesoni*-beds, where other small forms also occur. They are all pyritous, and lie in definite lines. It is also found badly preserved in the *armatus*-beds.

The inner whorls of these shells have generally perished, so that the young form is not well known. Some smaller specimens with rounder fronts may represent it.

Quenstedt's name would be preferable to Simpson's, as being better known, and well illustrated by the varieties of which the latter author made species, and it is used in our Part I.: nevertheless it cannot be adopted, having been pre-occupied by D'Orbigny for another species. It is probable that the *A. Ægion* of D'Orbigny is one of the varieties of this species; the sutures agree. The same may be said of *A. accipitris* of Buckman.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Easby. Sub-zone of *A. armatus*, Robin Hood's Bay.

Amaltheus lynx, *D'Orbigny*.

1844. 'Terr. Jur.' pl. 87, figs. 1–4.
Syn. 1855. *Lens*. Simpson. 'Foss. Y. L.' p. 80.

Geological position.—Zone of *A. Jamesoni*. Associated with *A. trivialis*. Robin Hood's Bay (6 ex.), and Huntcliff (2 ex.).

Amaltheus Huntoni, *Simpson.*

Plate II., fig. 8.

1843. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 83.
Syn. 1855. ? *Simplex*, ? *retentus*. Simpson, *loc. cit.* p. 84.

This is a small shell, and may be young. Its claim for specific distinction from others similar to it—which are considered to be the young of *A. oxynotus*—is its very peculiar sutures. These are similar to those of *A. trivialis* on the outside, having a general direction towards the centre, with a long and narrow lateral lobe; towards the inside, however, they bend remarkably forward, at the same time becoming simpler; so that this side is much nearer the aperture than the other. In general shape it is similar to *A. ferrugineus*, with a sharp front and obsolete sigmoidal striæ or radii. From Simpson's remarks it appears probable that the sutures of *simplex* and *retentus* may be similar to this, for which reason they are identified with it.

The only specimens I have seen closely are in the Leckenby Collection.

Geological position.—Zone of *A. oxynotus* or *A. Jamesoni.*

Amaltheus Oppeli, *Schlönbach.*

1863. 'Zeitschr. d. Deutsch. Geol. Ges.' t. xii. fig. 2.
1855. *Complanatus*. Simpson, *loc. cit.* p. 79 (non Sowerby, non Young and Bird).

Two in the Leckenby Collection, and one at Whitby, are all I have seen of this. They agree in all essential particulars with the above-quoted species.

Geological position.—Probably *oxynotus*-beds (3 ex.).

Amaltheus margaritatus, *Montfort.*

1808. 'Conch. Syst.' p. 90.
1875. Phillips. 'Geol. Yorks.' 3rd edition, pl. xiv. fig. 6.
Syn. 1818. *Stokesi*. Sowerby. 'Min. Con.' pl. clxci.
1822, 8. *Clevelandicus, vittatus, subnodosus, nodulosus*. Young and Bird. 'Geol. Surv.' pl. xiii. figs. 3, 7, 11.
1829, 35. *Vittatus*. Phillps, *loc. cit.* and pl. xiii. fig. 1.
1843. *Stokesi, depressus, vittatus, volutus, subnodosus*. 'Mon. Am.' and 1855, 'Foss. Y. L.' pp. 81, 82, 86, 90.

The great variety exhibited by this shell in passing from youth to age, and apparently from other circumstances, is well-known, and is fully illustrated by Yorkshire examples; but there is a certain facies about all the varieties which prevents their separation. They are all one species, yet it is extraordinary what anomalous forms it puts on, and we cannot be surprised at the number of synonyms. They may be represented,

however, in the main, under two heads—one the typical form, and the other the variety *subnodosus.*

In the first variety the outer whorl is broader ($\frac{1}{3}$ to $\frac{1}{2}$ the diameter), the sides forming a gentle curve, sometimes cut off abruptly within. The ribs are not very strong, but sometimes sharp, and ending in a small tubercle; but the largest, and therefore oldest, individuals are also the smoothest, approaching *A. Engelhardti.*

In the other variety the outer whorl is narrower, and more inflated, and the ribs become enormously conspicuous and strongly tuberculated, the front being almost round, except for the crenate keel. There is sometimes a sign of a second row of tubercles, and in this form the species approaches near to *A. spinatus*—this is the *vittatus* also of Young and Bird.

The specimens quoted from the *annulatus*-beds are young and nearly smooth forms, nevertheless their characteristic features are to be seen.

Geological position.—Zone of *A. margaritatus.* (Var. α). Hawsker, Staithes, Rockcliff, Hummersea, Huntcliff, Skelton Beck, Saltburn, Grosmont. (Var. β). Hawsker, Staithes. Zone of *A. spinatus,* Hawsker, Hutton Mines, Guisborough. Zone of *A. annulatus,* Skelton Park Pit, Guisborough.

Amaltheus Engelhardti, *D'Orbigny.*

1844. 'Terr. Jur.' pl. 66.
Syn. 1822, 8. ? *Lenticularis.* Young and Bird. 'Geol. Surv.' p. 269.
1843. *Lenticularis, reticularis.* Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' pp. 78, 79.

This involute, flat, obsoletely-radiated, longitudinally-striated, sharp-fronted species must by no means be united to *A. margaritatus.* It has the same characters throughout its life, which are approximated to, indeed, by some of the more lenticular of the *margaritati,* but never exactly manifested. Its keel is very obscurely and sometimes not at all crenated. Specimens occur from 1 inch to 4 inches diameter. The *lenticularis* of Young and Bird is insufficiently described, but the *reticularis* of Simpson is fairly established and has precedence. His publication, however, is so utterly inaccessible and unknown that it would be unadvisable to supplant by its names those of universally known species. If, however, D'Orbigny's *A. Engelhardti* should be regarded by any as a synonym for *A. margaritatus,* Simpson's name must stand for our present species.

Geological position.—Zone of *A. spinatus.* Not rare in the richer ironstone beds. Eston, Upleatham, &c. Hawsker.

Amaltheus spinatus, *Bruguière*.

1789. 'Encycl. Méthod.' tom. i. p. 40.
1843. D'Orbigny. 'Terr. Jur.' pl. lii.
1875. Phillips. 'Geol. Yorks.' 3rd edit. pl. xiii. fig. 8.

Syn. 1822, 8. *Hawskerensis*. Young and Bird. 'Geol. Surv.' pl. xiv. fig. 6.
1829, 35. *Hawskerensis*. Phillips, *loc. cit.*
1843. *Hawskerensis, Birdi, geometricus* (non Phil.), *subnodosus* (non Young and Bird). Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' pp. 90, 92, 89, 90.
1855. *Exasciatus* (also) Simpson, *loc. cit.* p. 90.

Like *A. margaritatus* this is a variable shell. When best developed it has quadrate whorls, a crenated keel between two shallow furrows, straight strong ribs with a tubercle inside and a double one outside, the pair being close together on the rib just at the bend on to the front. The varieties consist in the more or less numerous ribs, the strength or absence of the tubercles, and the amount of crenation of the keel. The smallest are most like those of the south of England; these varieties though well marked scarcely require names as there is no particular point of interest connected with them.

A specimen I refer to this species has occurred with *A. margaritatus* at Hawsker, it is of the flatter form more nearly allied to the latter. In its proper home this species grows to a large size, the largest known being 12 inches in diameter.

Geological position.—Zone of *A. spinatus* (characteristic) passim. Zone of *A. magaritatus*, Hawsker (1 ex.).

Amaltheus solitarius, *Simpson*.

Pl. VIII., fig. 2.

1855. 'Foss. Y. L.' p. 93.

Syn. 1822, 35, 75. *Geometricus*. Phillips. 'Geol. York.' pl. xiv. fig. 9 (non Young and Bird, non Oppel).

A very near ally of *A. spinatus*, but too far removed to be retained under the same name; compressed, nearly evolute, inner whorls ¼ concealed, outer whorl ⅓ diam., gently rounded, radii numerous, turning forwards both on the inside and outside, rather swollen near the outside; keel strong, protuberant, crenated; aperture roundly quadrate. The lateral lobe is much narrower than in *A. spinatus*. When young it is nearly smooth, or has a few linear radii, and is more involute. A large ammonite (10 inches) from the ironstone is identified with this rather than *A. spinatus*.

Phillips's name is the earliest, but his figure and statement of its horizon is misleading, and the name assigned has been used for other forms; it is therefore advisable to retain Simpson's name for this species which appears to be peculiar to Yorkshire.

Geological position.—Zone of *A. spinatus*, Eston, Hawsker (5 ex.).

Amaltheus (?) ferrugineus, *Simpson* (*non Oppel*).

Pl. VII., fig. 5.

1855. 'Foss. Y. L.' p. 79.
1822, S. *Complanatus.* Young and Bird, *loc. cit.* p. 268.
1855. *Conjunctivus.* Simpson, *loc. cit.* p. 78.
1868. ? *Planispira* or *disciformis.* Reynes. 'Ess. Géol. Pal. Aveyr.' pl. v. fig. 3, or pl. iii. fig. 5.

This is a pretty common species in the ironstone, but never grows to a large size. It is very similar to *A. Engelhardti*, but it has no longitudinal striæ, even when well preserved; it is uniformly convex though still lenticular; the inner edge is rounded, and the front is very slightly crenated. When young (½ inch) it is less involute and has a more rounded front. Its surface is covered by fine sigmoidal striæ collected into fasciculæ on the inner half of the whorl, and the species ought perhaps to be ranged with the *Harpocerata*. It cannot be identified very satisfactorily with any foreign figure, though several of Reynes's might represent it or its young.

Geological position.—Zone of *A. margaritatus*, Staithes (1 ex.). Zone of *A. spinatus*, Hawsker, Eston, Upleatham, &c.

GENUS PHYLLOCERAS.

Phylloceras Greenoughi, *Sowerby*.

1816. 'Min. Con.' pl. cxxxii.

Two large ammonites from the *oxynotus*-beds of Robin Hood's Bay are perhaps best recorded under this name; one has rather straight undulations passing over the front, and the curvature at the mouth decreases inside and increases outside so that the whorl becomes narrow and represents almost certainly *A. Salisburgensis* of Hauer. In the other, the undulations are obsolete. Both have some remote appearance of a keel, or rather raised line along the front; diameters 8 and 9 inches; they are, however, more compressed than the typical *P. Greenoughi*, but must be left there for the present.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay (2 exs.).

A specimen doubtfully identified with this occurred in the Upper *Bucklandi*-beds at Redcar.

Phylloceras Loscombi, *Sowerby*.

1817. 'Min. Con.' pl. clxxxiii.
1842. D'Orbigny. 'Terr. Jur.' pl. lxxv.
Syn. 1843. *Ambiguus* (adult), *Dennyi*, *arctus*, *nanus* ? (juv.), Simpson, 'Mon Am.' and 1855, 'Foss. Y. L.' 36, 38.

The adult shell is found in the *Jamesoni*-beds of Robin Hood's Bay, but I only know 3 specimens agreeing perfectly with this

species, one being of the variety having rounded ridges on the front like *P. ibex*. Oppel, Quenstedt, and D'Orbigny, unite in considering some small forms with sharper fronts, and often with constrictions, as the young of this, and they certainly agree in being involute with obsolete radii, and with moderately complicated sutures for their sizes; not having, therefore, sufficient reason for denying their being the young of *P. Loscombi*, I inscribe them as such, but Yorkshire specimens afford no evidence for this union.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay (3 adult and 4 young exs.); Huntcliff (5 exs.).

Phylloceras subcarinatum, *Young and Bird.*

1822, 8. (*Nautilus*). 'Geol. Surv.' pl. xii. fig. 9.
1829, 35, 75. Phillips. 'Geol. York.' pl. xiii. fig. 3.
1843, 55. Simpson, *loc. cit.* p. 37.
1868. Oppel. 'Pal. Mitth.' pl. xliv. figs. 1, 2.

An inflated form with a keel between two depressions.

Geological position.—Zone of *A. communis*, Whitby (8 exs.).

Phylloceras heterophyllum, *Sowerby.*

1819. 'Min. Con.' pl. cclxvi.
1829, 35, 75. Phillips. 'Geol. York.' pl. xiii. fig. 2.
1843, 55. Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 35.
Syn. 1822, 8. *Nautilus Whitbiensis.* Young and Bird, pl. viii. fig. 1.
1855. *Easingtonensis.* Simpson, *loc. cit.* p. 35.

The smaller individuals of this species are common, but perfect specimens of large size are rare. In the latter are seen radial undulations, covered with more marked striæ. Portions of this last whorl are often found separate; they are called locally "fans." Dumortier figures a fragment from the Rhone Basin under the name "corps de nature inconnue" ('Dép. Jur. Pt. 4.' pl. xlvii. fig. 9), but conjectures they may be parts of an unknown ammonite.

The *Easingtonensis* of Simpson is a rather more inflated variety than usual, with a longitudinal line along the centre of the whorl; but this latter feature may be very obscurely observed even in some of the most typical forms.

Geological position.—Zone of *A. serpentinus*, passim. Zone of *A. communis*, passim.

GENUS LYTOCERAS.

Lytoceras fimbriatum, *Sowerby.*

1817. 'Min. Con.' pl. clxiv.
Syn. 1843, 55. *Cornucopia.* Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 40.

The rarity of this genus has caused the species to be con-

founded. This differs from *L. cornucopia* in being more compressed and having finer radii.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay. Zone of *A. capricornus*, Staithes, Rockcliff, Huntcliff; fragments are common. Zone of *A. margaritatus*.—Staithes.

Lytoceras cornucopia, *Young and Bird.*

1822, 8. 'Geol. Surv.' pl. xii. fig. 6.
" " ? *Nitidus*, Young and Bird, *loc. cit.* p. 256.
Syn. 1829, 35, 75. *Balteatus*. Phillips. 'Geol. York.' pl. xiii. fig. 17.
1843, 55. *Fimbriatus*. Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 41.
" " ? *Fasciatus*. Simpson, *loc. cit.* p. 41.

This is generally of smaller size than *L. fimbriatum*, and better preserved. There may often be seen several specimens of *Discina reflexa* parasitic upon it. The *fasciatus* of Simpson is described as being more depressed. The *balteatus* of Phillips is probably an exaggerated form of a young *cornucopia*, but may be a distinct species with the *nitidus* of Young and Bird.

Geological position.—Zone of *A. serpentinus*, Whitby, Runswick. Zone of *A. annulatus*, Millington (1 ex.).

Lytoceras lineatum, *Schlotheim.*

1820. 'Petrefactenkunde,' p. 75.
1849. Quenstedt. 'Cephalopoden,' t. vi. fig. 8.
Syn. 1828. *Tenuicostatus, nitidus ?* Young and Bird, p. 253.
1843, 53. *Tenuicostatus, nitidus ?* Simpson. 'Mon Am.' and 'Foss.' Y. L.' p. 40, 41.

This species is similar to the last, but has very fine striations of great regularity and scarcely fimbriated. These too have parasitic *Discinæ*. Young and Bird's species was not figured and was imperfectly described.

Geological position.—Unknown, but probably zone of *A. serpentinus* (5 exs.).

Lytoceras jurense, *Zieten.*

1830. 'Versteinerungen Würtembergs,' tab. lxviii. fig. 1.
Syn. 1843, 55. *Gubernator*. Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 40.

The slight overlapping and the smoothness of the whorls distinguish this species. The Yorkshire forms have the inner edge rather more prominent, and the side a little flatter than the type.

Geological position.—Zone of *A. jurensis* (characteristic), Blea Wyke, in company with *Harpoceras variabile*. It also passes up into the sandy beds of the Blea Wyke with *Pecten silenus*.

Lytoceras Germanii, *D'Orbigny.*

1841. 'Terr. Jur.' pl. ci.

Geological position.—Zone of *A. jurensis*, Blea Wyke, a single fragment associated with *Harpoceras striatulum*.

GENUS STEPHANOCERAS.

Stephanoceras annulatum, *Sowerby.*

1819. 'Min. Con.' pl. ccxxii. fig. 5.
1828. Young and Bird. 'Geol. Surv.' pl. xii. fig. 11.
1843. Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 50.
1855. *Attenuatus vermis.* Simpson, *loc. cit.* pp. 51, 54.

When the shell is preserved the radii are seen to be flattened, so that the intermediate spaces look like grooves worked out with a fine tool. The radii in some slant forward very much. The *attenuatus* of Simpson is a variety with rather finer radii.

Geological position.—Zone of *A. annulatus*, passim.

Stephanoceras semicelatum, *Simpson.*

1843. 'Mon. Am.' and 'Foss. Y. L.' p. 50.

This is an allied species to *S. annulatum*, in which the inner whorls are nearly half concealed and the outer whorl is much compressed, and as if it were pinched towards the front. These differences appear to remain constant.

Geological position.—Zone of *A. angulatus*, Blue Bank, Grosmont, &c. (5 exs.).

With regard to the other *Stephanocerata* of the Upper Lias, they so merge into each other by variation that the boundaries of the so called species cannot be well defined. The names that follow appear to be sufficient to distinguish all the prominent varieties, although by dwelling on small differences a great many more species might be and have been made.

Stephanoceras commune, *Sowerby.*

1815 'Min. Con.' pl. cvii. figs. 2, 3.
1843, 55. Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 51.
Syn. 1815. *Angulatus.* Sowerby, pl. cvii. fig. 1.
1855. ? *Athleticus.* Simpson, *loc. cit.* p. 102.

This well-known form is somewhat variable, the two most noteworthy varieties differing considerably in the number of the ribs.

Geological position.—Zone of *A. communis*, passim.

Stephanoceras Holandrei, *D'Orbigny.*

1844. 'Terr. Jur.' tab. cv. fig. 1.

This includes those with more numerous ribs, though not so numerous as in *S. annulatum*, and having a pinched appearance like *S. semicelatum*. It would seem to be the earliest form of the genus in this district as it is met with in the *spinatus*-beds,

though it continues to the top of the *communis*-zone, but is not very plentiful.

Geological position.—Zone of *A. spinatus*, Hobhill (1 ex.). Zone of *A. communis*, Whitby.

Stephanoceras Braunianum, *D'Orbigny.*

1844. 'Terr. Jur.' tab. civ. fig. 3.

The Yorkshire shells that I refer to this species have fewer radii than are given by D'Orbigny's figure. They would appear to be included in *S. commune*, by Simpson.

Geological position.—Zone of *A. communis*, Whitby, Peak, &c.

Stephanoceras crassum, *Young and Bird.*

Plate VIII., fig. 5.

1822, 28. 'Geol. Surv.' p. 253.
1829, 35, 75. Phillips. 'Geol. York.' pl. xii. fig. 15.
1843, 55. Simpson. 'Mon. Am.' and 'Foss. Y. L.' p. 54.
Syn. 1843. *Andreæ.* Simpson. 'Mon. Am.' and 1855, 'Foss. Y.L.' p. 59.
1844. *Raquinianus.* D'Orbigny. 'Terr. Jur.' pl. cvi.
1855. *Annuliferus, incrassatus, crassulosus, crassibundus, crassiusculus, crassiusculosus, puteolus.* Simpson, *loc. cit.* pp. 50–58.

The family of shells allied to this species is so very variable that there is no mean between naming every minute difference as Simpson has done and throwing them into groups. I have chosen the latter method and unite all those which may be called inflated *S. commune*, under the present name, and those that stand in the same relation to *S. annulatum* under the next. They seem to develope tubercles indiscriminately, so that the feature is not a safe guide. Of the various local names, *annuliferus* represents one not far from *S. commune*, *incrassatus* is a young form with tubercles, *crassulosus* one with more remote radii, *crassibundus* I have not seen, but it appears to be a depressed form by its description, *crassiusculus* is rather stout with strong radii, *crassiusculosus* I have not seen—it may possibly not belong here—and *puteolus* is the most transverse, inflated and umbilicated of the series, and is the form figured. *Andreæ* must range among the tuberculated varieties.

Geological position.—Zone of *A. communis* and, perhaps, *serpentinus*, Whitby, Boulby, &c.

Stephanoceras Desplacei, *D'Orbigny.*

1844. 'Terr. Jur.' pl. cvii.
Syn. 1843. *Crassulus, Crosbeyi.* Simpson. 'Mon. Am.'
1855. *Crassulus, Crosbeyi, crassoides, crassifactus, Andersoni.* Simpson. 'Foss. Y. L.' pp. 54–58.

The several varieties of the last appear to be repeated here. The typical form is what D'Orbigny's figure of *S. Desplacei*

would be without the tubercles which occur, however, in a few Yorkshire specimens, and it is the *crassoides* and *crassifactus* of Simpson. The two earlier imposed names refer—*crassulus* to a young form, and *Crosbeyi* to the very involute form as *puteolus* of the last series. The *Andersoni* I have not seen.

Geological position.—Zones of *A. communis* and *serpentinus*, Whitby, &c.

Stephanoceras fibulatum, *Sowerby.*

1823. 'Min. Con.' pl. cccvii. fig. 2.
1828. 'Geol. Surv.' pl. xiii. fig. 9.
1843. Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 58.
Syn. 1822. *Armatus.* Young and Bird, *loc. cit.*

With the shape of *S. Holandrei*, the ribs of *S. annulatum*, this unites the peculiar looping of the ribs that leads on to the next series.

Geological position. — Zone of *A. communis*, Whitby, Lofthouse, &c.

Stephanoceras subarmatum, *Young and Bird.*

1822. 'Geol. Surv.' pl. xiii. fig. 3.
1823. Sowerby. 'Min. Con.' pl. cccvii. fig. 2.
1828. Young and Bird, *loc. cit.* pl. xiv. fig. 8.
1843. Simpson. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 60.
Syn. 1843. *Semiarmatus, vortex, vorticellus?* Simpson, *loc. cit.* pp. 59, 60.

There is a second series of shells inscribed under this name, similar to the *S. crassum* series, but having far more marked tubercles, spines, or fibulations, and having in general a quadrate and often transverse aperture. Simpson's *semiarmatus* would appear to be a monstrosity. His *vortex* is a variety with more distant ornaments, though he says the sutures are different. *Vorticellus* I have not seen, but its description is that of many *S. subarmata.*

Geological position.—Zone of *A. communis?* Whitby, &c.

Stephanoceras fonticulum, *Simpson.*

Plate I., fig. 10.

1855. 'Foss. Y. L.' p. 57.
Syn. 1855. *Foveatus.* Simpson, *loc. cit.* p. 57.

This is similar to *Æg. Grenouillouxi*, but the radii on the inside of the whorls are united, two and two, into tubercles, as in *S. fibulatum.*

The whole side of the shell is an umbilicus. Each tubercle has 3 or 4 ribs, corresponding to it on the front, which is transversely convex. It is an extreme form of *S. subarmatum*, as the variety *puteolus* is of *S. crassum*, but seems worthy of standing by itself.

Its resemblance to *Æg. Grenouillouxi* shows how *Ægoceras* and

Stephanoceras may approach each other, if these species are rightly assigned.

Geological position.—Probably zone of *A. serpentinus*, Whitby.

Stephanoceras crassescens, *Simpson.*

1855. 'Foss. Y. L.' p. 55.

This most remarkable Ammonite I should have taken for a monstrosity, if I had not seen five examples of it. Its inner whorls resemble those of the last species, except that the spines are longer, and the umbilicus not so deep, while the outer whorl gradually puts on the appearance of *S. Holandrei*, being compressed and without tubercles. The existence of such a form would appear to prove the close alliance of the whole series.

Geological position.—Zone of *A. communis*, Whitby.

Stephanoceras gracile, *Simpson.*

Pl. VII., fig. 8.

1843. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 54.

A small gregarious species, with the inner edges of the whorls rather prominent, sides flattish, the front elevated; numerous fine trenchant ribs, about the same in proportion as in *S. commune.* Aperture sub-pentagonal, as wide as high.

The whorls are slender and well separated, and there is no mistaking it for *S. commune.*

Geological position.—Zone of *A. serpentinus*, of which it is very characteristic, occurring in nests and on the shale, Whitby, Sandsend, Skelton.

GENUS HARPOCERAS.

Harpoceras Algovianum, *Oppel.*

Pl. VIII., fig. 1.

1862. 'Pal. Mitth.' p. 137.
1868. Reynes 'Essai de Géol. et de Pal. Aveyronnaises,' pl. ii. fig. 1.
Syn. 1828. *Nitescens.* Young and Bird, *loc. cit.* p. 257.
1843, 55. *Nitescens.* Simpson, *loc, cit.* p. 87.

Evolute, compressed, with oblong, rather depressed whorls: outer whorl $\frac{3}{10}$ diameter; inner whorls $\frac{1}{4}$ concealed; 24 to 32 moderately strong sigmoidal ribs, enlarging almost to a tubercle on the outside, where they bend forward and form an obsolete side-keel; front with a low, uncrenated keel between two very shallow furrows.

This has great resemblance to *H. striatulum*, but it is flatter, and the ribs are more conspicuous. Young and Bird did not figure nor fully describe their species, and Simpson's description

is not sufficiently accurate. As, therefore, Oppel's name has been illustrated by Reynes's beautiful figure, and the sutures are also in exact agreement, I have adopted the later name.

The specimen figured is not a typical example, but one which I refer to this species, although its ribs are stronger and the tubercles are more distinct; but this is probably due to size. This specimen recalls somewhat the appearance of *H. Levisoni.*

Geological position.—Zone of *A. margaritatus*, Hawsker, Staithes, Marske Mill, Saltburn, Rockcliff (rare).

Harpoceras concavum, *Sowerby.*

1815. 'Min. Con.' pl. xciv. fig. 2.
Syn. 1822. *Elegans.* Young and Bird. 'Geol. Surv.' p. 267 (non Sowerby).
1843, 55. —— pars. Simpson, *loc. cit.* p. 72.
1829, 35, 75. *Ovatus.* Phillips. 'Geol. York.' pl. xiii. fig. 10.

Although Sowerby's type was described from the Oolite above, yet the species which occurs in the *Annulatus*-beds of Yorkshire corresponds in all respects to his description. However, as the shell grows, the outer whorl leaves the umbilicus, and the inner whorls are more exposed. They then have a longitudinal line near the inner edge, as noticed by Simpson, though this is by no means peculiar to this species. Their shell was a very thin one. The ribbing is variable, and never well marked, often being almost reduced to striæ.

Although Sowerby's specimen was supposed to come from the Inferior Oolite of Ilminster, it is not impossible it may have come from the Lias of that locality. The shells named *concavus* in collections from the higher zone may be easily distinguished from the present, which is recognised all over Europe in the lower part of the Upper Lias.

Geological position.—Zone of *A. annulatus*, at the junction with the zone above, Runswick, Whitby.

Harpoceras aalense, *Zieten.*

1830. 'Versteinerungen Würtembergs,' pl. xxviii. fig. 3.
Syn. 1829, 35. ? *Sigmifer.* Phillips. 'Geol. York.' pl. xiii. fig. 4.
1855. *Rugatulus, ovatulus* ? Simpson, *loc. cit.* pp. 73, 76.

The combined characters of an untruncated inner edge to the whorls, and an irregularity in the ribbing, which is not strongly marked, suffice to separate this from others. It is, however, one of those smaller forms of which one can never be sure that one is not dealing with young individuals. The same shell, or one at this stage undistinguishable from it, occurs in the Inferior Oolite.

Geological position.—Zone of *A. serpentinus*, Whitby, Runswick, &c; also in the Inferior Oolite.

Harpoceras lythense, *Young and Bird.*

Pl. II., fig. 4.

1822, 8. 'Geol. Surv.' p. 267.
1829, 35. Phillips? *loc. cit.* pl. xiii. fig. 6.
1843, 55. Simpson, *loc. cit.* p. 74.
Syn. 1844. *Concavus?* D'Orbigny. 'Terr. Jur.' pl. cxvi.
1829, 35, 75. *Exaratus.* Phillips, *loc. cit.* pl. xiii. fig. 7.
1855. *Multifoliatus? Ceptophyllus.* Simpson, *loc. cit.* pp. 73, 80.

The typical form of this species has never yet been properly figured, that which Phillips gives not being sufficiently characteristic, and his figure of *A. exaratus* being much more like this species. The figure of D'Orbigny, who unites it to *H. concavum*, is the best, but not quite like the Yorkshire forms.

The inner whorls are not quite concealed; the inner edge of the last whorl is vertical; towards this edge the side of the whorl is longitudinally depressed, and almost smooth, whence the falciform ribs increase in size towards the front, which is almost rounded in the cast, but has the keel standing out sharp in the shell. The sides of the whorls are remarkably flat, though the rapid rise at the inner edge makes it, notwithstanding, a stout shell.

Geological position.—Zone of *A. communis*, Whitby. Passim.

Harpoceras simile, *Simpson.*

Pl. I., fig. 4.

1845. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 74.

The species, for which this name may be retained, is intermediate between *H. lythense* and the next to be described. It differs from the former in being inflated on the sides, instead of being flat; its umbilicus is larger, and the whorls decline at first gradually into it, and afterwards by a very short truncated portion, which, however, is nearly perpendicular; the greatest thickness of the whorl is near, but not quite at, the inner edge. It differs from *H. subconcavum* in the position of the greatest thickness of the whorl, and other characters detailed under the latter species.

Geological position. — Zone of *A. serpentinus*, Whitby, &c. (Simpson).

Harpoceras subconcavum, *Young and Bird.*

Pl. VIII., fig. 8.

1822, 8. 'Geol. Surv.' pl. xiii. fig. 5.
1843, 55. Simpson, *loc. cit.* p. 75.
Syn. 1828 *Boulbiensis?* Young and Bird, *loc. cit.* p. 267.
1843, 55. *Boulbiensis?* Simpson, *loc. cit.* p. 74.

The descriptions hitherto given of this species are not very

distinctive, but the shells identified with specimens so labelled at Whitby have marked characters. The greatest thickness of the whorls is at about $\frac{1}{4}$ of the distance from the inner to the outer edge; from this point the surface rapidly slopes towards the centre, bringing, so to speak, part of the whorl into the formation of the umbilicus. The inner edge is slanting, and the inner whorls are as much uncovered as in the last species, *i.e.* about $\frac{1}{4}$. The keel has a slight furrow on each side.

The artist has drawn 4 ribs too few in the figure, and has made the furrows of the front too deep.

Young and Bird thought their ***A. boulbiensis*** might be a variety of this, but I am not sure that some now so called do not belong to ***H. compactile.***

Geological position.—Zone of ***A. communis***, Peak, Boulby, &c.

Harpoceras exaratum, *Young and Bird.*

Pl. II., fig. 5.

1822, 8. 'Geol. Surv.' p. 266.
1829, 35, 75. Phillips. 'Geol. York.' pl. xiii. fig. 7.
1843, 55. Simpson, *loc. cit.* p. 72.
Non Dumortier. 'Dép. Jurass.' Pt. 4, pl. xii. fig. 1.
Syn. 1822, 28. *Elegantulus.* Young and Bird, *loc. cit.* p. 267. Simpson, *loc. cit.* p. 72.

The inner whorls of this species are about as much covered as in ***H. lythense***, from which it differs in having flatter whorls, the whole shell being more compressed, and the consequently little fall into the umbilicus is made by a very slanting truncation, this last feature distinguishing it from ***H. Mulgravium***, with which it has been sometimes united. The radii are so broad and flat that the ornaments may be better described as consisting of sigmoidal grooves, neatly cut on the surface, whence the name.

Geological position.—Zone of ***A. serpentinus***, Whitby, &c.

Harpoceras cæcilia, *Reinecke.*

Pl. II., fig. 6.

1818. 'Nautil. et Argonautas,' fig. 76, 77.
Syn. 1843, 55. *Elegans* (pars) *ovatulus?* Simpson, *loc. cit.* pp. 72, 76.
1829, 35, 75. *Ovatus?* Phillips, *loc. cit.* pl. xiii. fig. 10.

The general appearance of this shell is not unlike that of ***H. concavum***, but the inner whorls are more exposed ($\frac{1}{4}$), and the umbilicus is not so deep. The ribbing is not very conspicuous.

The specimens referred to this species are not the young of ***H. serpentinum***, with which D'Orbigny united the ***Naut. cæcilia*** of Reinecke; but they agree well with the figure and description recently given by Dumortier of Reinecke's species, as well as with his own. The ribs have a tendency to be fasciculated within, and the inner edge is ***nearly*** vertical.

The *A. ovatus* of Phillips is neither the *A. ovatus* of Young and Bird, nor the *A. opalinus* of Reinecke, to which it is referred in the last edition. It may represent a variety of species, but is, perhaps, meant for this.

Geological position.—Zone of *A. serpentinus*. Passim.

Harpoceras primordiale, *Schlotheim.*

Pl. II., fig. 7.

1820. 'Petrefactenkunde,' p. 65, and 'Nachtrag,' pl. ix. fig. 2.
Syn. 1822, 28. *Ovatus*, Young and Bird, *loc. cit.* pl. xiii. fig. 4.
1843, 55. *Ovatus*, Simpson, *loc. cit.* p. 76 (non *ovatus* Phillips).

Some confusion exists about this species. Schlotheim's description is not very complete, and his figure appears to have been overlooked. The latter represents a semi-evolute shell, with the sides of the whorls uniformly rounded. Notwithstanding this, on account of its fine striæ, it has been taken for *H. opalinum* of Reinecke, which is nearly involute, and has the inner edge truncate. Young and Bird's figure of *A. ovatus* represents an extraordinary form, if one belonging to this species at all, though their description is good. This seems to have guided Phillips, who represents quite a different shell as *A. ovatus*, though he still calls it *A. opalinus*. Simpson's description of *A. ovatus*, however, refers to the true species, and is a good one. The *A. primordialis* of D'Orbigny probably represents *H. opalinum*. The amount of involution varies, but is never so much as in *H. opalinum*, and the inner part of the whorl sometimes falls so suddenly as to be almost angular. The outer part of younger shells shows well-marked sigmoidal ribs, but the final stage of ornaments arrived at at different periods is always that of fine sigmoidal striæ, and the keel is sharp.

Geological position.—Zone of *A. communis* (towards the base), Whitby.

Harpoceras elegans, *Sowerby.*

1815. 'Min. Con.' pl. xciv. (non Phillips, Young and Bird, nec Simpson
1829, 35, 75. Phillips, *loc. cit.* 3rd ed. pl. xiii. fig. 12.
Syn. 1822, 8. *Mulgravius*. Young and Bird, *loc. cit.* pl. xiii. fig. 8.
1843, 55. *Mulgravius* (pars). Simpson, *loc. cit.* p. 73.
1829, 35. *Mulgravius*. Phillips, *loc. cit.*
1875. *Falcifer*. Phillips, *loc. cit.* (non Sowerby).
1844. *Complanatus*. D'Orbigny. 'Terr. Jur.' pl. cxiv.
1856. *Subplanatus*. Oppel. 'Juraform.' p. 244.

Oppel has shown that D'Orbigny's name, *complanatus*, has not the authority of Bruguière, whose species belonged to upper Jurassic rocks; and since the *elegans* of Sowerby is the next oldest name, it must come into use, although Oppel invented the new name, *subplanatus*, under the idea that D'Orbigny's was not the same as Sowerby's species: but if it were not, then

Young and Bird's name would have priority. Simpson's *Mulgravius* includes the next species also.

Geological position.—Zone of *A. communis*, Whitby, &c.
„ *A. serpentinus*, Runswick.

Harpoceras serpentinum, *Reinecke.*

1818. 'Nautili et Argonautæ,' figs. 74, 75.
Syn. 1820. *Falcifer, Strangewaysi.* Sowerby. 'Min. Con.' pl. ccliv.
1843, 55. *Mulgravius* (pars) *alternatus.* Simpson, *loc. cit.* pp. 73, 86.

The *A. falcifer* of Sowerby appears to me rather to be the young of this than of the last; its true young state is very like the *H. cæcilia*, with which Sowerby's species has often been united.

The *A. alternatus* of Simpson is a curious form, in which the inner sides of the whorls are undulating, but it clearly belongs here.

Geological position.—Zone of *A. serpentinus* (characteristic). Passim.

Harpoceras bifrons, *Bruguière.*

1789. 'Encyclop. Méthod.' p. 40.
1843. D'Orbigny. 'Terr. Jur.' pl. lvi.
Syn. 1815. *Walcottii.* Sowerby. 'Min. Con.' pl. cvi.
1822, 8. *Hildensis.* Young and Bird, pl. xii. fig. 1.
1843, 55. *Walcottii, hildensis.* Simpson. 'Mon. Am.' and 'Foss. Y.L.' p. 99.

Young and Bird considered their *hildensis* as synonymous with the *Walcottii* of Sowerby; but Simpson distinguishes two varieties, to which he assigns the separate names, his *A. hildensis* having a more triangular front, and occurring in the jet-rock.

Geological position.—Zone of *A. communis.* Passim.
„ *A. serpentinus.* (Simpson.)

Harpoceras Levisoni, *Simpson.*

1843. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 99.
1874. Dumortier 'Dépôts Jurassiques,' Pt. 4, pl. ix. figs. 3, 4.

Dumortier, who gives a very good figure of this species, says it is very common in the Rhone district. It is a very near ally to *H. bifrons*, differing from it in having no longitudinal furrow, the ribs either reaching the inner margin, or being nearly obsolete there, and they consequently show more of their sigmoidal character. The furrows also on the front are not quite so deep.

Geological position.—Zone of *A. serpentinus*, Whitby, Westerdale.

Harpoceras latescens, *Simpson.*

Pl. VII., fig. 7, *a, b.*

1843. 'Mon. Am.' and 1855, 'Foss. Y. L.' p. 100.
Syn. 1856. *Sæmanni*. Oppel. 'Jur.' p. 242.

More evolute than *H. Levisoni*, and leading on from thence to *H. subconcavum*, the outer whorl is ⅗ths the diameter, and has 30 sigmoid ribs (the figure has 4 too few), which on the inner whorls are rather fasciculated; the front and its two furrows are very neat.

This is obviously the *A. Sæmanni* of Oppel, which he records from Yorkshire, and says differs from *A. bifrons* by its more numerous ribs, which reach the inner edge, the first of which characters prevents its identification with *H. Levisoni*. See Dumortier, *loc. cit.* pl. 13, fig. 4.

Geological position.—Zone of *A. serpentinus*, Whitby.

Harpoceras striatulum, *Sowerby.*

1823. 'Min. Con.' pl. ccccxxi. fig. 1.
1843, 55. Simpson, *loc. cit.* p. 87.

Geological position.—Zone of *A. jurensis*. Peak. Young and Bird state that it is also found in the dogger at Glaizedale; but we have not met with it even in the sandy beds at Blea Wyke; but it is quite characteristic of the beds below.

Harpoceras compactile, *Simpson.*

Pl. VIII. fig. 6.

1855. 'Foss. of Y. L.' p. 75.
Syn. 1830. ? *Depressus*. Zieten. 'Versteinerungen Würtembergs.' pl. v. fig. 5 (non Bruguière).

This species appears to be almost peculiar to Yorkshire, as I have not seen anything like it figured from elsewhere except that referred to, which, however, has more numerous ribs. Zieten's name cannot be adopted as it was pre-occupied. The shell figured by him has been united by authors to his *A. discoides*, which is, however, distinguished from the present by being without a true keel. *H. compactile* is excessively depressed, has a very small umbilicus, in which scarcely any of the earlier whorls can be seen; the inner truncated edge is slanting, and has a slight rim round it; the keel is bordered by two slightly-marked depressions. The radii are numerous; though variable, sigmoidal, most marked on the outside, and not so strong as in *H. lythense*. Although very thin, it is more convex than *H. lythense*, its nearest ally, because the front is so excessively sharp.

It is possible that some of the shells called *A. boulbiensis* may be only inflated varieties of this.

Geological position.—Zone of *A. jurensis*, Peak, where it is not uncommon, and very characteristic.

Harpoceras lectum, *Simpson.*

Plate VIII. fig. 7.

1843. 'Mon. of Amm.' and 1855 'Foss. Y. L.' p. 75.
Syn. 1874. *Lympharum.* Dumortier. 'Dép. Jur.' pt. 4, pl. xvi. figs. 5, 6.

Involute, compressed, whorls uniformly rounded, only the slightest possible truncation visible on the inner edge; the keel separated from the sides by a longitudinal line. The radii and striæ are almost obsolete, quite invisible on the cast.

It is satisfactory to find this species so exactly represented on the same horizon in France. The nearest ally is *H. serrodens* of Quenstedt, from which it differs by being more involute, and having a separate keel. It is always of small size.

Geological position.—Zone of *A. jurensis.* Peak.

Harpoceras Beanii, *Simpson.*

1843. 'Foss. Y. L.' p. 77.
Syn. 1822, 8. *Obliquatus.* Young and Bird, *loc. cit.* p. 265.
1843, 55. *Obliquatus.* Simpson, *loc. cit.* p. 76.
1844. *Variabilis.* D'Orbigny. 'Terr. Jur.' pl. cxiii.

This was well described by Simpson in 1843, and though it is undoubtedly the same as the well-figured species of D'Orbigny, I do not consider this as sufficient reason for ignoring the priority of the former, especially as his description is closer to the Yorkshire forms of the shell, which are more involute than D'Orbigny's figure. The knobs on the inner edge which characterise it in youth disappear with the ribs in age, and it becomes flatter, and almost smooth; in which stage it was imperfectly described by Young and Bird as *A. obliquatus.* In extreme youth this species is very similar to the young forms of *H. Murchisonæ* or *H. aalense.*

Geological position.—Zone of *A. jurensis*, Peak.

Harpoceras comense, *Von Buch.*

1831. 'Pétrefactions Remarquables,' pl. ii. figs. 1–3.
1874. Dumortier. 'Dép. Jur.' pt. iv. pl. xx. figs. 1–3 (non D'Orbigny, Quenstedt, &c.).
Syn. 1855. *Fabalis, pinguis.* Simpson, *loc. cit.* pp. 77, 100.

I should not have been able to identify the Yorkshire shell described by Simpson as *A. fabalis*, with the *H. comense* of Von Buch, except for the figure and description given by Dumortier,

which shows more clearly than those of the original author what form the shell may take. This may be described as having narrower whorls than *H. Beanii*, and the radii much stronger. The shape of the aperture, and its less inflation, distinguish it from *H. insigne*, as also do its lobes.

Geological position.—Zone of *A. jurensis*, Peak.

Harpoceras insigne, *Schubler in Zieten.*

1830. 'Versteinerungen Würtembergs,' pl. xv. fig. 2.
1844. D'Orbigny. 'Terr. Jur.' p. cxii.
Syn. 1843. *Phillipsii.* Simpson. 'Mon. Am.' and 1855, 'Foss. L.Y.' p. 78.

The distinguishing feature of this species, its triangular aperture, is well shown by specimens in the Leckenby Collection, which were obtained in the Holderness drift, and presumably came from the Yorkshire Lias, and also by the *Phillipsii* of Simpson, whose locality is unknown: the latter is more involute than the full-grown type. Dr. Wright quotes this species from bed No. 6 at Blea Wyke, but we have not found it *in situ.*

Geological position.—Probably zone of *A. jurensis.*

Harpoceras rude, *Simpson.*

1843. 'Mon. Am.' and 1855 'Foss. Y. L.' p. 87.
Syn. 1874. *Malagma.* Dumortier. 'Dép. Jur.' pt. 4, pl. xxii.

I should have considered this an abnormally rough and open *H. comense*, if the same form had not been figured by Dumortier, which proves its persistence.

The inner whorls are scarcely concealed; the radii are very strong and nearly straight, and rise in pairs or threes from irregular swellings on the inside, with occasional separate ones.

Geological position.—Unknown. Probably zone of *A. jurensis* (1 ex.).

I add here the descriptions of such of Mr. Simpson's species as I have not seen, or of which I am in some doubt as to their being well established.

Ammonites peregrinus, p. 36.

"A fragment with a finely rounded back, equal to a semicircle, then a sudden depression on the side, a flat space, and a shallow umbilicus; siphuncle well displayed where the shell is wanting, transverse striæ numerous, flat, in places nearly obsolete, diameter 3 inches."

This may possibly be a large *Ægoceras planorbe*, but the description is obviously insufficient.

Ammonites labratus, p. 36.

"Inner volutions concealed, outer whorl nearly $\frac{4}{3}$ the diameter; umbilicus small with an elevated rim; striæ numerous, fine, slightly fimbriated or roughened, aperture ovate; diameter, 2½ inches." "This also greatly resembles *A. heterophyllus*, but it has a rim round the umbilicus, and the septa are more simple and of a different form. Specimen imperfect."

The difference of the sutures seems to indicate that this is not a *Phylloceras*, but I cannot guess its nature.

Ammonites erratus, p. 37.

"Much depressed; volutions 4, inner ones $\frac{8}{10}$ths concealed, outer whorl half the diameter, sides flatted; radii twice bent, unequal, pass over the back; aperture ovate; diameter, $\frac{4}{10}$ inch." "This Ammonite reminds one of *A. elegans* or *A. exaratus*; but it is entirely destitute of a keel. The shell is thin and of a greyish colour, and where it is absent, the cast is black and shining. Jet rock, U. L.—Whitby."

I have seen this specimen, but should not venture to name a shell which may be only an abnormal individual of one of the species quoted, without seeing more than one.

Ammonites turriculatus, p. 59.

"Volutions 6 or 7, much exposed, outer whorl $\frac{1}{4}$ the diameter, sides depressed, inner margin prominent, sharply rounded; radii numerous, fine, annular, pass over the back undivided, with short ones there frequently introduced; on the outer edge of the whorls a row of tubercles or short knobs at intervals of 5 or 6 radii; aperture sub-quadrate, diameter $2\frac{1}{2}$ inches. This rather a robust shell. The radii are fibulated at the tubercles, and nearly obsolete at the aperture. Syn. *A. Davæi*, Young and Bird."

I have seen this specimen, and though it has a similar appearance to *Stephanoceras Davæi*, I cannot feel sure it is more than an extreme variety of *S. fibulatum*. No specimens of the former have ever been seen by us in their proper horizon.

Ammonites sinuatus, p. 62.

"Volutions exposed, outer whorl $\frac{1}{3}$ the diameter, sides convex; radii obtuse, separated by rather wide concave spaces, commence on the inner margin, slightly incline towards the aperture, and then in the opposite direction from a row of tubercles on the outer margin, nearly obsolete on the back; aperture ovate or subquadrate; diameter, $4\frac{1}{2}$ inches. A fragment, L. L."

I have seen this specimen in the Whitby Museum; it agrees fairly with the description, but I cannot identify it with certainty.

Ammonites vetustus, p. 88.

"Volutions 5, inner ones nearly concealed, outer whorl $\frac{1}{3}$ the diameter, radii strong, obtuse, nearly obsolete on the inner whorls; keel an obtuse angle, aperture ovate; diameter $1\frac{1}{10}$ inches. The shell is roughish, the cast smooth, and the foliations of the septa simple, in general form it comes near to the more depressed varieties of *Am. striatulus*, but the whorls are numerous, and the shell is without striæ. I believe it is from the lower lias at Robin Hood's Bay."

I have not seen this shell, and can only suggest its possible relation to *Ægoceras longipontinum*.

In addition to these are:—*A. delicatus* and *A. anguiformis*; *A. petricosus*, a double-spined *Ægoceras*; *A. alienus*, a broad whorled *Arietites*, which are probably young shells, from their size, but of which I am not able to suggest the adult.

FAMILY NAUTILIDÆ.

GENUS NAUTILUS.

Young and Bird noticed two species of this genus, one of which I regard as doubtful, besides the two Ammonites that they called Nautili. Phillips re-named the doubtful form, and Simpson added two more, but without sufficiently distinguishing characters.

Nautilus striatus, *Sowerby*.

1817. 'Min. Con.' pl. clxxxii. (non Simpson).
Syn. 1828. *Undulatus*. Young and Bird, *loc. cit.* p. 272.
1829, 75. *Annularis*. Phillips. 'Geol. York.' pl. xiii. fig. 18.
1855. Simpson, *loc. cit.* p. 33.

Although Simpson identified Young and Bird's *astacoides* with this, the identification will not stand. The present species has a more open umbilicus and more quadrate aperture, and is strongly striated. It seldom grows here to great size, the largest being about 5 inches. A variety described by Simpson under the same title may, perhaps, really belong here.

I have examined the type of Phillips's *N. annularis*, and it is only a variety of this species.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Cliff, Redcar, Eston Pit; *A. Bucklandi*, Redcar, Marske, Ellerbeck.

Nautilus intermedius, *Sowerby*.

1816. 'Min. Con.' pl. cxxv.
Syn. ? 1855. *Astacoides*. Simpson. 'Foss. Y. L.' p. 33.

This is also a striated Nautilus, but its front is gently truncated, and its umbilicus is a little wider than in the last. As Simpson's *astacoides* is said to have its "back flatted," it may be meant for this.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay (3 exs.).

Nautilus araris, *Dumortier*.

1869. 'Dép. Jur.' Pt. 3, pl. vi. fig. 7.

This Middle Lias Nautilus is distinguished by the aperture becoming narrower towards the front before making the convexity, and by the obliquity of its septa. Its umbilicus is about as open as in the last.

Geological position.—Zone of *A. armatus*, Robin Hood's Bay. One poor example.

Nautilus astacoides, *Young and Bird.*

1828. 'Geol. Surv.' pl. xiii. fig. 2.
1829, 35, 75. Phillips. 'Geol. York.' pl. xii. fig. 16.

The umbilicus in this species is smaller than in any other from this formation, and the height of the aperture is greater compared to its breadth. Both these features distinguish it from *N. striatus*. There are also few, if any, striæ, though the shell is seldom seen. It attains a diameter of more than 6 inches.

Geological position.—Zones of *A. communis* and *serpentinus*, Whitby, Lofthouse.

Nautilus jurensis? *Quenstedt.*

1858. 'Jura.' pl. xli. fig. 1.
Syn. 1855. *Heterogeneus*. Simpson, *loc. cit.* p. 33.

Simpson gave his name to a specimen which shows a second apparent siphuncle on the inside, a phenomenon which is not by any means confined to one species; indeed, it may be seen in specimens of *N. astacoides*, and has long been noticed, Montfort in 1808 having founded a genus *Bisyphites* upon this. As Simpson gives no other description, his species is irrecognisable; the particular specimen, however, happens to have a wide umbilicus and a transverse aperture; characters which separate it from *N. astacoides*, and attach it to such a form as *N. jurensis*. Its aperture is uniformly convex, and has no flattening, or it might be identified with *N. Toarcensis* (D'Orb.), of which Quenstedt's species is generally considered a synonym.

Geological position.—Unknown, but probably Upper Lias.

ORDER DIBRANCHIATA.

Family Teuthidæ.

GENUS BELOTEUTHIS.

Beloteuthis subcostatus, *Münster.*

1844. 'Beiträge,' No. VI. tab. 5, fig. 2.
1849. (*Loliginites*). Quenstedt. 'Cephalopoden,' tab. 32, figs. 7, 8. See Woodward's 'Manual of the Mollusca,' pl. ii. fig. 8.

Pen 10 inches by 4, of a rhomboidal form, with two parabolic wings. The sides below these wings are slightly curved. The ends of the wings curve by a double flexure into the part beyond, and reach to about ½ the length of the pen. Midrib large, broadening towards the end; the sides thrown into gentle

Geological position.—Zones of *A. Bucklandi*, Robin Hood's Bay, Redcar, Millington; *A. oxynotus*, Robin Hood's Bay, Redcar.

Belemnites calcar, *Phillips.*

1865. *Loc. cit.* pl. ii. fig. 5.

This is not recorded by its author from Yorkshire, but a few examples found by us agree fairly, though not exactly, with the description. They are very short, somewhat stout, pyramidal, have striated apices, and are remarkable for the immense size of the alveolus compared with the guard.

Geological position.—Zones of *A. Bucklandi*, Redcar (1 ex.), Coatham (1 ex.); *A. oxynotus*, Robin Hood's Bay (1 ex.).

Belemnites penicillatus, *Sowerby.*

1828. 'Min. Con.' pl. dxc. figs. 6, 9.
1865. Phillips. 'Brit. Bels.' pl. i. fig. 2.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 2.

The typical forms have an irregular guard, which is quadrate and ends irregularly, and has depressions or grooves on the sides. Smaller specimens are more conical and less irregular, and approach *B. acutus.* Indeed some, which are, perhaps, best referred to this species, differ only from the last-named form by being more circular in section. These may be the *B. grandævus* of Phillips. The species is very nearly allied to *B. compressus* (Stahl), but is not so hastate.

Geological position.—Zones of *A. Bucklandi*, Dalton Road (not typical); *A. oxynotus*, Warter; *A. armatus*, Robin Hood's Bay.

Belemnites dens, *Simpson.*

1855. 'Foss. Y. L.' p. 30.
1865. Phillips. 'Brit. Bels.' pl. ii. fig. 6.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 3.

Only one specimen appears to be known of this, which is in the Whitby Museum. One with this name attached by Professor Phillips in the Cambridge Museum belongs to the next, nearly allied, species, and does not show the characters of this.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay (Simpson).

Belemnites palliatus, *Dumortier.*

Pl. IV., fig. 4.

1869. 'Dép. Jur.' pt. 3, pl. v. figs. 9–17.

A very remarkable form, in which the alveolus is very large, and the guard very thin. The end of the guard has a triangular

section, and slightly recurved apex; there are two dorso-lateral depressions, and an irregularity on the ventral side. The whole is conical, with the sides concave, the angle of the cone being about 30°. Length 1½ inch., which is twice its greatest breadth.

The phragmocone occupies ⅓ of the whole length, the septa are numerous, and it is eccentric, lying near one side of the triangle, opposite to the direction in which the apex is curved.

It differs from *B. calcar* by its concave sides and triangular section, and is not so robust, and from *B. dens* by its want also of the peculiar ornamentation.

Geological position.—Sub-zone of *A. armatus*, Robin Hood's Bay (2 exs.).

Belemnites elegans, *Simpson.*

1855. *Loc. cit.* p. 31.
1867. Phillips. 'Brit. Bels.' pl. xx. fig. 50.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 11 (non fig. 8).

Moderately stout, sub-hastate, sharp-pointed, with two obscure dorso-lateral grooves and striæ. Length 4½ inches, which is seven times its greatest breadth. Phillips's figures in the 'Geology of Yorkshire' are mismatched; fig. 11 is meant for this species.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay, Huntcliff (common).

Belemnites charmouthensis, *Mayer.*

Pl. IV., fig. 5.

1866. 'Jour. de Conch.' 3rd series, tab. vi. p. 364.
1869. Dumortier. 'Dép, Jur.' pt. 3, pl. v. fig. 8.
Syn. 1855. *Clavatus.* Simpson, *loc. cit.* p. 30 (non Blainville).

Allied to *B. clavatus*, but thicker. The part near the alveolus is quadrangular, and the apex of the guard is obtuse. Like most of the Belemnites of this epoch, it has two shallow longitudinal depressions, disappearing towards the apex. Mayer says the section is circular, but this agrees with Dumortier's figure in every other respect.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay, Huntcliff.

Belemnites araris, *Dumortier.*

Pl. IV., fig. 6.

1869. 'Dép. Jur.' pt. 3, pl. iv. figs. 20–25.

Guard short, delicate, very slightly fusiform, with no apical, and only faint lateral lines; section rather angular, not depressed; length 2 inches, which is six times its breadth.

Although this is a common species, it does not appear to have been described by Phillips. It agrees with his *B. dorsalis* in shape, but has no dorsal groove such as he describes in that species, and is from a different horizon.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay, Huntcliff; sub-zone of *A. armatus*, Robin Hood's Bay, Warter.

Belemnites virgatus, *Mayer.*

Pl. IV., fig. 7, *a*, *b*, *c*.

1863. *Loc. cit.* tab. iii. p. 190.
1869. Dumortier, *loc. cit.* pl. iv. figs. 1–6.
Syn. ? 1868. *Nitidus.* Phillips, *loc. cit.* pl. xiii. fig. 34.

Guard moderately long, cylindroidal, with eccentric acuminate but blunt apex; contour irregular, section rather quadrangular; with bands on the sides not reaching the apex, not strong enough to be called furrows. Length 2¼ inches, which is seven times the breadth. Alveolus short. The apex in one specimen is beautifully pitted like honeycomb, apparently by folds of the mantle (see fig. 7, *c*). I suspect this is the *B. nitidus* quoted by Phillips from the Lower Lias, Robin Hood's Bay, in his 'Geology of Yorkshire' (1875), p. 262.

Geological position.—Zones of *A. Jamesoni* and *A. armatus*, Robin Hood's Bay; *A. margaritatus*, Staithes.

Belemnites clavatus, *Blainville.*

1827. 'Mem. sur les Belemnites,' pl. iii. fig. 12.
1866. Phillips, 'Brit. Bels.' pl. iii. fig. 7.
Syn. 1855. [illegible] Simpson, *loc. cit.* pp. 30, 31.
1875. [illegible] Phillips, 'Geol. York.' pl. xxviii. figs 4–6.

The type of a family in which the guard is more or less swollen near the apex; the alveolar region is the narrowest, and is sometimes quadrate, and there only are marks or furrows seen on the surface. The length and breadth and shape are variable, giving rise to the different local varieties; but they are not to be separated by any constant character.

Geological position.—Zones of *A. J*[illegible], Robin Hood's Bay; *A. cap*[illegible], Huntcliff; *A.* [illegible], Skinningrove, Huntcliff, Staithes, [illegible] Fscr[illegible].

Belemnites aspergillum, *B*[illegible].

Syn. 18[illegible] [illegible] N[illegible] Hist. Rep. [illegible]

Guard [illegible] six times as long as the greatest breadth, [illegible] at

the apex, which is hollowed out to a greater or less extent. No marks or furrows visible in general.

This species has the form of *B. inæquistriatus*, but is without furrows, and has a peculiar apex. Simpson's names are both pre-occupied. I regard the two as really the same species, though the apex of *B. perforatus* is most excavated, and the guard a little more depressed.

Geological position.—Zones of *A. capricornus* and ? *A. Jamesoni*, Robin Hood's Bay.

Belemnites apicurvatus, *Blainville.*

1827. 'Mém. sur les Bel.' pl. ii. fig. 6.
1866. Phillips. 'Brit. Bels.' pl. vi. fig. 16.
Syn. 1855. ?*Repandus.* Simpson. 'Foss. Y.L.' p. 31.
1866. *Inæqualis.* Simpson. 'Geol. and Nat. Hist. Rep.' p. 216.
1868. *Inæqualis.* Phillips. 'Brit. Bels.' p. 91.

Apex sharp, bent towards the back; with two visible and two obsolete apical furrows when perfect; alveolar region slightly expanded; sides not equally convex.

Phillips states that *B. inæqualis* of Simpson is similar to the *B. paxillosus numismalis* of Quenstedt ('Ceph.' tab. 23, fig. 21), and belongs to the same group as *B. apicicurvatus*; remarks which lead me to doubt whether it is different to those I should identify with the latter.

Geological position.—Zones of *A. Jamesoni*, Huntcliff, Robin Hood's Bay; *A. capricornus*, Huntcliff; *A. margaritatus*, Staithes; *A. spinatus*, Eston, Staithes.

Belemnites cylindricus, *Simpson.*

1855. 'Foss. Y. L.' p. 29.
1868. Phillips. 'Brit. Bels.' pl. xx. fig. 52 P.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 14.

Guard elongate, moderately robust, cylindrical, with two short dorso-lateral grooves, and sometimes striæ on the ventral side. Length 4½ inches, which is six times the breadth. It is not so stout as *B. elongatus*, which is more deeply furrowed and somewhat hastate.

Geological position. — Zones of *A. margaritatus*, Hawsker; *A. spinatus*, Runswick, Hobb Hill; *A. annulatus*, Whitby, Staithes, Crag Hall, Skelton Park.

Belemnites Milleri, *Phillips.*

1866. *Loc. cit.* pl. viii. fig. 19.
Syn. ? 1855. *Ferreus* (pars) Simpson, *loc. cit.* p. 29.

Smooth, elongated, subfusiform; apex acute; length 6 times the breadth. Although Phillips describes this species from the Inferior Oolite sands, one which cannot be distinguished from it

certainly occurs in the Middle Lias, on which horizon it has been found also in France by Dumortier. Perhaps it is included in Simpson's *B. ferreus*.

Geological position.—Zones of *A. margaritatus*, Huntcliff; *A. spinatus*, Upleatham.

Belemnites breviformis, *Voltz.*

1830. 'Obs. sur les Belemnites,' pl. ii. figs. 2-4.
1866. Phillips. 'Brit. Bels.' pl. iv. figs. 9, 10.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 5 (bis), 8 (non fig. 11).

A short cylindroidal guard, with two obscure lateral grooves often nearly obsolete. Varieties numerous, the apex being blunter, or the guard being more elongate.

Geological position.—Zones of *A. capricornus*, Hummersea, Easby; *A. margaritatus*, Hawsker; *A. spinatus*, Eston, Hawsker, Runswick, Barf Hill, Market Weighton; *A. annulatus*, Staithes, Skelton; *A. serpentinus*, Sandsend.

Belemnites longiformis, *Spec. nov.*

Pl. IV., fig. 8, *a*, *b*.

Small, elongate, compressed, subhastate; length 11 times the breadth, with two obscure furrows at the apex, which is recurved. It has also continuous, more or less marked depressions in the alveolar portion. Length 3½ inches. It differs from *B. microstylus* and *B. clavatus* in its great compression and its furrows, and from *B. virgatus* in being more elongate and fusiform also, though it is very near some of Dumortier's figures of the latter species.

Geological position.—Zones of *A. margaritatus*, Staithes (1 ex.); *A. spinatus*, Grosmont, Eston, Kettleness.

Belemnites acuminatus, *Simpson.*

1855. 'Foss. Y. L.' p. 29.
1866. Phillips. 'Brit. Bels.' pl. ix. fig. 29.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 10.
Syn. 1855. *Ferreus*. Simpson. 'Foss. Y.L.' p. 29.
1866. *Politus*. Simpson. 'Geol. and Nat. Hist. Rep.' p. 216.

Moderately stout subhastate without furrows; section nearly circular; apex produced to a narrow point beyond the natural ending of the curve that forms the side.

B. ferreus is placed as a synonym, on the authority of Phillips. *B. politus* is a little stouter, passing to *B. pollex*, and has some obscure depressions near the apex; but, nevertheless, I think its place is here, by its general form and slightly-produced point.

Geological position.—Zones of *A. spinatus*, Runswick; *A. serpentinus*, Whitby.

Belemnites rudis, *Phillips.*

See Pl. IV., fig. 9.

1868. 'Brit. Bels.' pl. xvi. fig. 42.
1875. 'Geol. of York.' pl. xxviii. fig. 13.
Syn. 1855. *?Conicus.* Simpson. 'Foss. Y. L.' p. 29.

Guard cylindrical, or subconical; blunt in the adult; no striæ or furrows; shorter than *B. Milleri.*

There are some smaller specimens in the ironstone figured in Pl. IV., fig. 9, of whose nature I am doubtful; they are pointed, with subquadrangular section and lateral depressions. They look like the young of *B. virgatus*, but that species has not yet occurred in full size, and there is an appearance about these as if they would grow rather to *B. rudis.*

Geological position.—Zone of *A. spinatus*, Eston, Hawsker, Hob Hill.

Belemnites pollex, *Simpson.*

1855. 'Foss. Y. L.' p. 27.
1866. Phillips. 'Brit. Bels.' pl. ix. fig. 20.
1875. Phillips. 'Geol. York.' pl. xxviii. fig. 9.

Guard very obese, with a rounded, umbilicated apex; a somewhat short depression on the ventral side. Length 3½ inches, breadth 1 inch.

Geological position.—Zone of *A. communis*, Peak. [*A. Jamesoni*, Staithes (Phillips).]

Belemnites microstylus, *Phillips.*

1868. 'Brit. Bels.' pl. xiii. fig. 31.

Guard very slender, and elongated, greatly swelling towards the apex; no grooves. Its excessive slenderness distinguishes it from *B. clavatus*, and its want of compression from *B. longissimus.*

Geological position.—Zone of *A. spinatus*, Eston (3 exs.).

Belemnites compressus, *Stahl.*

1824. 'Correspondenzblatt, &c.' pl. xxxiii. fig. 4.
1866. Phillips. 'Brit. Bels.' pl. iii. fig. 8.

Guard short, irregular, swollen near the apex, which is blunt, and has two lateral grooves; section quadrangular.

Geological position.—Zone of *A. spinatus*, Eston (2 exs.).

Belemnites paxillosus, *Schlotheim.*

1820. 'Petrefactenkunde,' p. 46.
1866. Phillips. 'Brit. Bels.' pl. vi. fig. 15; pl. xx. fig. 52.

Guard stout, cylindrical, similar to that of *B. cylindricus*, but with 2 strong, short, dorso-lateral grooves and several strong

striæ; apex often slightly recurved; length 3½ inches, or more, which is 5 times the breadth.

Geological position.—Zone of *A. spinatus*, Kettleness (2 exs.).

Belemnites scabrosus, *Simpson.*

1866. 'Geol. and Nat. Hist. Rep.' p. 216.
1868. Phillips. 'Brit. Bels.' pl. xx. fig. 51.

Under this name I inscribe a Belemnite of great rarity, found in the *annulatus*-beds at Hawsker. It is very elongate, very slightly fusiform, with a striated apex and 3 obscure grooves; the sides are flattened. Its length is 6¾ inches, which is 13 times its breadth. It is not thick enough for *B. tripartitus*. The single specimen figured by Phillips was said to come from the "upper part of the Lower Lias, Robin Hood's Bay;" it is much more fusiform, and shows no striæ; the resemblance, however, is still very great.

Geological position.—Zone of *A. annulatus*, Hawsker (J. F. B.) [*A. Jamesoni*, Robin Hood's Bay (Phillips)].

Belemnites vulgaris, *Young and Bird.*

1822. 'Geol. Surv.' pl. xiv. fig. 1, and 1828, pl. xv. fig. 1.
1855. Simpson. 'Foss. Y. L.' p. 28.
1868. Phillips. 'Brit. Bels.' pl. xvi. figs. 40, 41.
1875. Phillips. 'Geol. York.' pl. xxvii. fig. 11.
Syn. 1829, 35. *Compressus*, Phillips. 'Geol. York.' pl. xii. fig. 21.
1855. *Glaber, densus, inclusus, curtus.* Simpson. 'Foss. Y. L.' pp. 24, 25, 29.

Guard robust, cylindrical, regular, with two lateral and one ventral furrow, and often with striæ. The apex is apt to be destroyed. Like all common forms, it is very variable, and it is only where some constant character is found that we can separate them. I believe all the above synonyms are amongst its varieties. In some the ventral groove is replaced by a few strong striæ; one has a narrow dorsal sulcus; another has the ventral furrow very deep in the middle of the guard; others have the furrows almost obsolete. Some from the Middle Lias are more elongated, passing on to *B. paxillosus.*

Geological position.—Zones of *A. spinatus*, Eston, Hawsker; *A. communis*, Whitby, Boulby, Lofthouse, &c.

Belemnites levidensis, *Simpson.*

Pl. III., figs. 3, *a*, *b*, and 7.

1855. 'Foss. Y. L.' p. 29.

This is constantly to be distinguished from *B. vulgaris*. It is stouter, and much more compressed; the ventral furrow is also more often absent. Length 3⅓ times the breadth.

Geological position.—Zone of *A. communis*, Whitby, &c.

Belemnites latesulcatus, *Phillips.*

1866. 'Brit. Bels.' pl. v. fig. 14.
Syn. 1855. *Obtusus, robustus.* Simpson, 'Foss. Y. L.' pp. 27, 28.

Guard short and very stout, quadrangular, with depressions along two sides the whole length; apex obtuse.

Some exactly correspond to Phillips's figure, but others are less stout, and show less distinct furrows, forming the passage to *B. breviformis.* Length of one of these 3½ inches, which is 4 times its breadth.

Simpson's names have the priority over Phillips's, as there cannot be a doubt that they refer to the same species; but as descriptions of Belemnites, unless very full and accurate, are not sufficient for their identification, I adopt the newer, better illustrated name.

Geological position.—Zone of *A. annulatus*, Skelton Park Pit (? only).

Belemnites validus, *Simpson.*

Pl. III., fig. 4.

1855. 'Foss. Y. L.' p. 28.

This has a family likeness to the last, but though as stout, has a far greater length; the apex is not so pointed, and the lateral depressions are reduced to one feeble one. Length 6 times the diameter; cylindrical, rounded, not compressed.

Geological position.—Unknown; probably Zone of *A. annulatus* (3 exs.).

Belemnites striolatus, *Phillips.*

1868. 'Brit. Bels.' pl. x. fig. 25.
1875. 'Geol. York.' pl. xxvii. fig. 3.
Syn. 1855. *Substriatus.* Simpson, *loc. cit.* p. 27.

Guard conical, flattened, finely striated at the apex. It differs from *B. lævis* in being more conical, and the striæ more numerous and regular. It has no grooves.

Geological position.—Zones of *A. serpentinus*, Whitby, Skelton Park; *A. annulatus*, Boosbeck.

Belemnites lævis, *Simpson.*

1855. 'Foss. Y. L.' p. 25.
1868. Phillips. 'Brit. Bels.' pl. x. figs. 23, 26.
1875. Phillips. 'Geol. York.' pl. xxvii. figs. 4, 5.
Syn. 1855. ?*Trivialis.* Simpson, *loc. cit.* p. 26.

Guard robust, moderately long; only a few striæ at the apex. Some differ from Phillips's description in having a lateral compression and a section narrower behind than in front. Some show passages into trisulcate forms, others have no furrows at

Belemnites tripartitus, *Schlotheim.*

1820. 'Petrefactenkunde,' p. 48.
1868. Phillips. 'Brit. Bels.' pl. xi. fig. 28.
1875. Phillips. 'Geol. York.' pl. xxvii. fig. 8.
Syn. 1855. *Trisulculosus, incisus, spicatus.* Simpson, *loc. cit.* pp. 26, 27, 29.

This is stouter than *B. subaduncatus*, longer than *B. vulgaris*, and differs from *B. cylindricus* in being tripartite. The first two synonyms are on the authority of Phillips, and *B. spicatus*, which I have seen, cannot be separated from *B. incisus*.

Geological position.—Zone of *A. serpentinus*, Whitby.

Belemnites elongatus, *Sowerby.*

1828. 'Min. Con.' pl. dxc. fig. 1.
1866. Phillips. 'Brit. Bels.' pl. vii. fig. 17.
Syn. 1866. *Turris?* Simpson. 'Geol. and Nat. Hist. Rep.' p. 216.

I have not seen any specimen that I could certainly refer to this species, but insert it here because Phillips catalogues it ('Geol. Yorksh.,' 1875, p. 262), and the description of *B. turris* suits it exactly.

Geological position.—Upper Lias; horizon unknown. Whitby.

Belemnites longisulcatus, *Voltz.*

1830. *Loc. cit.* pl. vi. fig. 1.
1868. Phillips. 'Brit. Bels.' pl. xix. fig. 47.
Syn. 1855. *Carinatus.* ? Simpson, *loc. cit.* p. 28.

This species is quoted by Phillips ('Geol. York.,' 1875, p. 262) as occurring at Whitby. Simpson's description of *B. carinatus* corresponds exactly to the apical portion of it.

Geological position.—Zone of *A. serpentinus*, Whitby.

Belemnites inæquistriatus, *Simpson.*

1855. 'Foss. Y. L.' p. 24.
1868. Phillips. 'Brit. Bels.' pl. xix. fig. 48.
Syn. 1855. *Concavus, erosus.* Simpson, *loc. cit.* pp. 24, 25.

Sides concave, quickly tapering over the alveolus, then slowly; apex imperfect, long lateral grooves, section oval.

The whole of this entry is on the authority of Prof. Phillips. I have seen no specimen except in Whitby Museum.

Geological position.—Zone of *A. serpentinus*, Saltwick.

Belemnites tubularis, *Young and Bird.*

1822. 'Geol. Surv.' pl. xxii. fig. 6.
1829, 35, 75. Phillips. 'Geol. York.' pl. xii. fig. 20.
1855. Simpson. 'Foss. Y. L.' p. 23.
1868. Phillips. 'Brit. Bels.' pl. xiv. fig. 36.
Syn. 1866. *Productus.* Simpson. 'Geol. and Nat. Hist. Rep.' p. 216.

A well-known, excessively elongate form, part being com-

pressed to a flat layer, having been soft; the proportion flattened is variable. The character relied upon for the species *B. productus* name, the roughness of the alveolar region, cannot be allowed to have so much weight.

Geological position.—Zone of *A. serpentinus*, Saltwick.

Belemnites crossotelus, *Blake.*

Syn. 1822. *Compressus.* Young and Bird, *loc. cit.* p. 15, fig. 5 (non Stahl, &c.).
1855. *Compressus.* Simpson, *loc. cit.* p. 24.

Stout, with the apex imperfect, the shell apparently having been soft inside half-way down, so that the end is flattened and undulated in its present state like a fringe. Length 4 times the breadth; that is, 3 times as broad as *B. tubularis.*

Young and Bird's name was, no doubt, the first; but as it has been but little used, I think it better to invent a new name for a not common Belemnite than to keep one more "*compressus*" in the field.

Phillips appears to have considered this equivalent to *B. inæquistriatus*; but the specimens I apply the present name to are much broader, and altogether different.

Geological position.—Zone of *A. serpentinus*, Saltwick.

Belemnites Voltzii, *Phillips.*

1868. 'Brit. Bels.' pl. xvii. fig. 43.
1875. 'Geol. York.' pl. xxvii. fig. 9.
Syn. 1830. *Compressus.* Voltz, *loc. cit.* pl. v. figs. 1, 2.
1868. *Ventralis.* Phillips, *loc. cit.* figs. 44, 45.
1855. ?*Telum.* Simpson, *loc. cit.* p. 27.

Acutely conical, with two lateral furrows, and a ventral furrow in some cases; length 5 times the greatest breadth. The presence or absence of a ventral furrow cannot be made a specific difference in this case without doing the same in the case of *B. vulgaris*; and as in the latter, at least, the furrow has many stages of obscurity before being obliterated, it is best to divide neither.

B. telum belongs either to this or the next.

Geological position.—Zones of *A. serpentinus*, Whitby; *A. communis*, Whitby, Lofthouse.

Belemnites athleticus, *Simpson.*

1855. 'Foss. Y. L.' p. 28.

A conical tripartite form, with inflated, unequal sides, depressed; these last two characters separate it from *B. Voltzii*, with which alone it can be confounded. It is equally near, however, to *B. inornatus* of Phillips.

Geological position.—Zone of *A. jurensis*, Peak.

[DUBIOUS SPECIES.]

Belemnites répandus. Simpson. 'Foss. Y. L.' p. 31.

"Sub-fusiform, rather depressed; bent towards one side; apex pointed." This description is obviously insufficient: it may be *B. longiformis.*

Belemnites tenuis. Simpson. 'Foss. Y. L.' p. 31.

"Slender, elongated, tapering towards both ends." Probably a fragment of *B. clavatus.*

Belemnites limatulus. Simpson. 'Geol. Rep.' p. 216.

"Conical, much compressed, apex obtuse, with about five principal deep triangular furrows and others smaller, and many distinct striæ; texture close and smooth. Length, 6 inches; width at the base, 1 inch. The sides of the guard are nearly straight, and the transverse section very elliptical. The alveolus expands and the larger grooves extend about ½ the length from the apex." This might be *B. inæquistriatus*, but it is too stout. No locality is given, and we may be dealing with a non-Liassic shell.

On the Range and Succession of the Belemnites.

The oldest known Belemnitic remains are two large circular phragmocones in the *angulatus*-beds of Redcar possibly belonging to *B. infundibulum*, but not to *B. acutus.* One is remarkable for its size, having a diameter of 1 inch, and thus apparently belonging to a larger form than any yet known in the Lower Lias.

The earliest complete Belemnite in the Yorkshire Lias is a short conical form, with a circular section; moderately stout, of irregular outline, and striated apex,—*B. infundibulum.* Following this is a still shorter guard, with a roundly-triangular section and large alveolus,—*B. calcar.* Possibly derived from these, but appearing about the same time as the latter, comes the depressed *B. acutus* with the length of the first, but the form of the last. There are several passages, however, from the *B. acutus* to *B. infundibulum*, the former being in some cases almost circular, in others very depressed, with a lateral groove. This form holds its own for some time. Commencing in the upper part of the *Bucklandi*-beds, it goes through the whole of the *oxynotus*-zone, where it is very plentiful, and only at the top of the latter do we find any recognisable alteration. Here it grows more elongate, more depressed, and sometimes more marked with a lateral line, and so becomes *B. penicillatus.* The other forms also remain to the top of the *oxynotus*-beds, the *B. calcar* becoming (probably, for only one specimen has been seen) *B. dens*, and the forms thus enumerated constitute the whole Belemnitic fauna of the Yorkshire Lower Lias.

At the commencement of the Middle Lias an entirely new set of Belemnites appears, only remotely connected with their predecessors. A very rare form, however, *B. palliatus*, with a triangular section, concave side, and very large proportionate alveolus, continues directly the line of *B. calcar.* From *B. penicillatus, infundibulum*, and *acutus* 3 main branches arise: 1st.

the rounder forms of *B. acutus* elongate, and the lateral depression becomes obscure; and we get the subconical, and only very remotely hastate, *B. elegans*, sometimes striated at the apex. Again, the more swollen forms of *B. penicillatus* become also elongated, more hastate, in some instances considerably more so, distinctly precasting *B. clavatus*, while the lateral depressions remain fully developed, and make the alveolar region quadrate. This form best deserves the name of *B. charmouthensis*; it is not *B. compressus*, though like some of Phillips's figures referred to that species, nor yet fully developed into *B. clavatus*, the passages to *B. penicillatus* not being wanting. The 3rd main branch consists of smaller forms, derived from the smaller hybrids between *B. acutus* and *B. infundibulum*, but they affect the lateral depressions very distinctly, and are influenced by the general tendency to become hastate, and thus form *B. araris*. There is also a rarer form, derived from the flatter varieties of *penicillatus* by elongation, which, from the distinctness of the lateral depressions, has been called *B. virgatus*. Towards the top of the *Jamesoni*-beds both *B. araris* and *B. charmouthensis* lose their distinctive characters, and the variable *B. clavatus* takes their place, characterised by the roundness of the alveolus, the lateral depressions being confined to that region, while the amount of swelling of the guard and the bluntness of the apex is very variable. This may, perhaps, be called the junction-form between those characteristic of the Lower Lias and those of the Middle, as it can be traced up from the former and lived on with many of those of the latter. When this becomes almost the only representative, viz. in the upper part of the *Jamesoni*-beds, we have quite a new form introduced, which cannot be traced to any of the preceding: this is *B. apicicurvatus*. In this the section is circular, and the whole guard elongated and cylindrical, gradually tapering to a rather bent apex, where there are two well-marked furrows and some striæ, thus belonging to an altogether different type, which is subsequently largely developed. Here also arises in *B. aspergillum* the first indication of a series of Belemnites with imperfect apices, which occur in the Upper Lias. *B. clavatus*, however, becomes changed in the *capricornus*-zone in the direction of *B. apicicurvatus*, becoming larger, stouter, and with two well-marked grooves, though the striæ disappear, the whole remaining, however, so similar to its original form as not to warrant separation. This double furrowing seems, to a certain degree, characteristic of the Middle Lias, most Belemnites presenting this feature. The zone of *A. capricornus* is thus a barren one in Belemnite forms, no new ones being introduced, and with *B.* [illegible], *apicicurvatus*, and *clavatus* as the only representatives. The two latter of these continue in their original forms into the *margaritatus*-beds, when *B. clavatus* dies out. *B. apicicurvatus*, however, is now accompanied by other members of its family, viz. the so-called *B.* [illegible], which appears to be only the Yorkshire form of *B.* [illegible], and another outlying form, *B. Milleri*, in which the apex is not at all recurved, and

the striæ and grooves are wanting, or nearly so. *B. apicicurvatus* varies somewhat in shape, often being more curved than this alliance would suggest. In this zone also appears what seems to be a modification of the original *B. elegans* in the same direction as to *B. virgatus*, less hastate, but with lateral depressions reaching the apex, and much compressed, leading on to a remarkable form, *B. longiformis*, a small species, axis comparatively long, and very compressed, with two obscure lateral grooves at the apex. There also arises in these beds a new type, only connected with the others by its double grooves, sometimes present, but with an axis comparatively short, section as broad as long, and well-formed, pointed apex, *B. breviformis*. It is this form that becomes the most abundant and leading form in the zone above, and here, accordingly, it has many varieties, which depend on the distinctness of its lateral furrows, its relative thickness, its compression, and the production of its apex. Those forms in which the section has become circular, the figure stout, and the apex produced, have been separated as *B. acuminatus*, but the passage-forms are numerous; in some of these the form becomes almost subhastate, and they appear to have some relation to *B. Milleri*. More directly connected, however, perhaps is a small form, much larger proportionally, without ornament, with a circular section and obtuse apex, which must be at present inscribed under that name, similar to this when young; and arising, perhaps, from nearly the same origin, is *B. rudis*, of more conical shape when adult, which appears to be carried still further in the same direction to *B. pollex*, which occurs in the Upper Lias. Two other Belemnites occur in this horizon only whose origin cannot be directly traced, viz. *B. compressus* and *B. microstylus*. *Belemnites apicicurvatus* and *cylindricus* both continue, and another variety of the same family, thicker in proportion even than *B. cylindricus*, but with more marked ornaments, as in *B. apicicurvatus*, but with blunt apex—*B. paxillosus*, may also be recognised. It is probably from the same source that the earliest examples of tripartite Belemnites arise, as they do in the zone of *A. spinatus*, by *B. vulgaris* in its most elongated, circularly-sectioned form; in these the three grooves are clear; but in subsequent Upper-Lias forms the ventral one is obscure, possibly from atavism. *B. longiformis* also continues, and is probably the precursor of a passage-form leading on to one of the striated Belemnites of the Upper Lias, *B. striolatus*. In this passage-form the apex is striated, but the shell is flat, of similar proportionate length to either, but without any *well-marked* grooves.

This completes the list of the most varied Belemnitic fauna in the Lias. The Upper Lias commences with forms that have remained from earlier times, *B. breviformis* becoming scarce, and *B. cylindricus* very common, being the most characteristic Belemnite of the *annulatus*-beds. Passing from the form of *B. pollex* without grooves towards a Belemnite of the jet-rock, *B. latesulcatus*, we have also in the *annulatus*-series a stout bisulcate

shells and callous columella they resemble *Rotella* and *Helicina*, to which genera they had been referred by earlier authors.

This genus bears the same relation to *Pleurotomaria* that *Helicina* does to *Trochatella*, and *Rotella* to *Turbo Cochlicarina* of Brown, and includes the species *C. expansa*, *C. solarioides*, *C. compressa*, and *C. polita* of Sowerby; but the diagnosis will equally apply to *Rotella* and *Helicina*, the author having overlooked its true alliances, the characters relied on being the sub-discoidal form and the callosity of the base.

Cryptænia expansa, *Sowerby*.

1821. *Helicina expansa*. 'Min. Con.' t. cclxxiii. fs. 1-3.
Syn. 1828. *Helix cirroidea*. Young and Bird. 'York. Coast,' p. 248, t. xi. f. 4.
1855. *Turbo cirroides*. Simpson. 'Foss Y. L.' p. 103.

This species is the most widely diffused of the Liassic examples of the genus, though not selected by Deslongchamps for a type. It rejoices in a great variety of titles, having been successively placed in eight different genera, and with five specific names. Sowerby described it in 1821 under the name *Helicina expansa*; M. Deshayes in 1831 named it *Turbo callosus*; in 1836 Rœmer believed it to be a terrestrial shell, as Young and Bird did in 1828, and called it *Helix expansa*; whilst Brown referred it to *Rotella*, and Agassiz in his French edition of Sowerby's 'Mineral Conchology' made it the type of his genus *Ptychomphalus*. It was not till 1848 that M. Deslongchamps recognised its affinity to *Pleurotomaria*, but substituted the specific name of *suturalis*: a retrograde step was taken by Brown in 1849, who created the genus *Cochlicarina* for its reception; finally, in 1865, M. Deslongchamps the younger raised the sutural Pleurotomarias of his father to the rank of a genus under the name *Cryptænia*, and included therein the present species.

C. expansa is too well known to need description in this work, but its chief characters are:—the acuminate spire, the elevated rim on the carinated whorls, and the largely convexed underside: the sutural band occupies the keel.

Helicina polita may be a variety, but *H. solarioides*, which has been usually so considered, I regard as a distinct species.

Geological position.—Zones of *Am. spinatus*, Hawsker, Eston, Upleatham; *Am. margaritatus*, Marske Mill.

Cryptænia consobrina, *Spec. nov.*

Pl. X., fig. 22, *a*, *b*.

Shell heliciform, depressed; spire very slightly elevated, acute, composed of five nearly flat whorls; the last whorl is considerably enlarged, and is bordered by an obtuse keel, occu-

pied by the sutural band. Surface marked by curved transverse lines. Base flattened, but impressed towards the centre. Aperture squarish.

Dimensions.—Diameter $1\frac{1}{10}$ inches; height of last whorl $\frac{3}{8}$ inch.

This species is intermediate in form between *C. expansa*, Sow., and *C. complanata*, Deslong., differing from the former in the absence of the carina, and the ridge-like fold surrounding the posterior suture; it is more depressed, and the last whorl proportionately larger, but less so than is the case with *C. complanata*.

Geological position.—Zone of *Am. spinatus*, Cleveland, main seam of ironstone, Eston, Upleatham, Hob Hill, Skinningrove, Northcote, Belman, and Hutton Mines.

Cryptænia solarioides, *Sowerby*.

Pl. X., fig. 2, *a*, *b*.

1821. *Helicina solarioides*. 'Min. Con.' t. cclxxiii. f. 4.
Syn. ? 1867. *Jamoignaca, Wehenkeli*. Terquem and Piette. 'Le Lias Inf. de l'Est de la France,' t. iv. f. 19, and figs. 29–31.

This species has very generally been quoted as synonymic with *C. expansa*, from which it differs in the absence of the carina on the last whorl, and by being more discoid. I have compared my specimens with Sowerby's type in the British Museum, and am satisfied of their specific identity. Sowerby gave no locality for his example.

The shell is heliciform, subdiscoid, with an acute summit; spire depressed, composed of 6 sub-concave whorls, with a convex fold around the posterior suture; outer edge of last whorl occupied by a broad-depressed convex band, sometimes truncated; ornamented with longitudinal striæ, sometimes obsolete, or confined to the upper or under-side only; under-side convex, with a distinct impressed area beneath the marginal band; provided with a large callosity, and imperforate, sutural band situated on the edge of the whorl.

Dimensions of largest specimen:—height $\frac{11}{20}$ inch, breadth $\frac{18}{20}$ inch. Number of examples examined, several dozens.

Geological position.—Zones of *Am. angulatus*, Redcar (a few examples), Millington (2 exs.), Cliff (1 ex.); *A. Bucklandi* (Lower and Middle beds), Redcar (common).

Cryptænia rotellæformis, *Dunker*.

1847. (*Pleurotomaria.*) 'Palæontographica,' vol. i. t. xiii. f. 12, p. 111.

Geological position.—Zones of *Ammonites angulatus*, Cliff (1 ex.); *A. Bucklandi*, Redcar (1 ex.).

The Redcar specimen is incomplete, and, if it be correctly named, is an unusually large example of the species. It has a breadth of base of one inch, and a height of three-quarters of an inch, the whorls sub-rotund.

Cryptænia nucleus, *Terquem.*

1854. (*Pleurotomaria.*) 'Paléontologie de Hettange,' t. v. f. 5.

Geological position.—Zone of *Am. angulatus*, Cliff (on authority of J. F. Blake; specimens since lost).

Pleurotomaria obesula, *Spec. nov.*

Pl. X., fig. 6.

Syn. 1872. *Trochotoma striatum.* Blake. 'Quart. Jourt Geol. Soc.' vol. xx. p. 14.
? 1861. *Trochotoma striatum.* Stoliczka. 'Akad. der Wissenschaften,' vol. xliii. p. 193; tom. v. f. 2 (non Pl. striata, Sow. 1836).

Shell turbinate, conical, of seven rounded whorls, ornamented by numerous longitudinal threads, alternately large and small, crossed by closely-set curved striæ. Sutural band wide, flat, ornamented with three flat longitudinal threads, and curved lines of growth. Base flattened exteriorly, thence slightly arched to the umbilicus, which is narrow, and extending the whole length of the spire, similarly ornamented as the rest of the shell. Aperture sub-quadrate. On the last whorl there are about 30 large and small costæ above the sutural band, and 10 below it, whilst on the base they amount to from 30 to 40. The longitudinal lines are fewer in number on the posterior whorls, and the reticulated ornament is more open; the sutural band on the fourth whorl is without longitudinal lines.

Stoliczka expresses a doubt as to the generic position of his *Trochotoma striatum*, mainly relying on his interpretation of the occasional interruptions to the continuity of the sutural band as a justification for assigning the species to the genus *Trochotoma*. This particular character is not exhibited by any of the specimens collected by my coadjutor, and no reason can be urged against the species belonging to *Pleurotomaria*. Other slight differences between the English and Austrian examples induce me to regard them as belonging to distinct species. Nevertheless, should they ultimately prove identical, then the specific name here given should be adopted, because, as the generic name, *Pleurotomaria*, must be applied, the specific one, *striata*, cannot be employed, as it is already occupied by at least two other species.

The slight differences between *Pleurotomaria obesula* and *Trochotoma striatum*, judging from Stoliczka's figure, are that the former has a flatter base, more spiral lines, a less ornate sutural band. Dimensions of largest specimen: height and diameter of base, 1⅝ inches; height of last whorl, ⅝ inch.

Geological position.—Zone of *Am. angulatus*, Cliff near Market Weighton (5 exs.).

Pleurotomaria similis, *Sowerby.*

Pl. IX., fig. 4.

1816. *Trochus similis.* 'Min. Con.' pl. cxlii.
Syn. 1818. *Trochus Anglicus.* Sowerby, pl. ccxxxviii.
1855. *Trochus Anglicus.* Simpson. 'Foss. Y. L.' p. 103.
Pleurotomaria Anglica of most authors.

P. similis is a conical shell, with squarish whorls, with tubercles on their angles, longitudinally costated and transversely striated. Specimens vary much in form and in the details of the ornamentation.

Usually the shell is a little higher than broad, but the proportion of the height to the breadth varies from 100 to 90 and 100 to 85. The sutural band, which is invariably raised above the general surface, is usually carinated sharply or bluntly. The number of longitudinal costæ above the posterior row of tubercles is usually 3; the size of the tubercles is also variable. Very young examples possess a narrow umbilical groove. The largest specimen has a height of 2·54, and a breadth of 2·2 inches.

Specimens of Pleurotomaria from the ironstone resemble this species, but when in condition for critical comparison, they seem to agree better with *P. undosa* and *P. rustica.*

Geological position.—Zones of *Am. angulatus*, Redcar (not rare); *A. Bucklandi*, Redcar (common), Marske Bay [*Lower Lias*, Leppington, and Robin Hood's Bay (Phillips)].

Pleurotomaria basilica, *Chapuis and Dewalque.*

1853. 'Terr. Sec. de Luxembourg,' t. xiii, f. 2, p. 94.

This name I give to certain shells similar to *P. similis* in ornament, but which are as broad as high, with nearly straight sides and a wide umbilicus. It does not grow to one-fourth the size.

Geological position.—Zone of *A. Bucklandi*, Redcar (12 exs.).

Pleurotomaria Hennocqui, *Terquem.*

1855. 'Paléontologie de Hettange,' p. 275, t. xvi. f. 12.

I have much hesitation in referring a single specimen of a large Pleurotomaria with subconvex whorls, depressed at the angles, to *P. Hennocqui*, Terquem. The great disparity of size does not admit of a close comparison; nevertheless, rather than create a new species, I am content to regard the Yorkshire shell as an adult example of *P. Hennocqui.* Dimensions: height and diameter of base, 2¾ inches.

Geological position.—Zone of *Am. Bucklandi* (probably), Marske Bay (1 ex.).

Pleurotomaria foveolata, *Deslongchamps.*

Pl. IX., fig. 2.

1848. *P. foveolata*, var. *trochoidea.* 'Mém. Linn. Soc. Normandie,' vol. viii. t. xv. f. 2.

Geological position.—Zone of *Am. capricornus*, Huntcliff, Staithes.

Pleurotomaria procera, *D'Orbigny, pars.*

Pl. IX., fig. 24.

Syn. 1848. *P. foveolata*, var. *pinguis.* Deslongchamps, *loc. cit.* t. xv. f. 6.
1855. *Trochus pusillus.* Simpson. 'Foss. Y. L.' p. 103.

Geological position.—Sub-zone of *Am. armatus*, Robin Hood's Bay (2 exs.).

Pleurotomaria helicinoides, *Römer, sp.*

Pl. X., fig. 7.

1836. (*Turbo.*) 'Ool. Geb.' t. xi. f. 13, p. 150.
1871. (*Pleurotomaria.*) Brauns. 'Untere Jura,' p. 278.
Syn. 1848. *Turbo canalis.* Münster. Goldfuss. 'Petref. Germ.' t. cxciii. f. 12.
1867. *Trochus carinatus.* Moore. 'M. and U. Lias,' t. iv. f. 24, 25, p. 91.

My independent examination of this species had led me to employ the generic title of *Pleurotomaria*, recently applied by Brauns; no specimen showing the slit has passed through my hands, but all that I have examined exhibit a sutural band on the upper carina of the body-whorl.

Geological position.—Zone of *A. spinatus*, Eston and Upleatham Mines (9 exs.), Hawsker (2 exs.).

Pleurotomaria tectaria, *Tate.*

Pl. IX., fig. 26.

1870. 'Irish Lias Foss.' p. 17.

"Shell turbinated, conical, scalariform; spire acute; whorls, six, subquadrate; last whorl with two prominent carinæ, separated by a slightly concave area; surface of whorls strongly, longitudinally, striated; upper part of each whorl cancellated by very fine, oblique striæ; siphonal band very narrow, occupying a slight groove on the upper carina, ornamented with three longitudinal striæ; base imperforate, concentrically costated; aperture subquadrangular. Dimensions: total length, $\frac{9}{10}$ inch; breadth of last whorl, $\frac{6}{10}$ inch; height of body-whorl, $\frac{4}{10}$ inch."

Related to *P. concava*, Martin, of the L. Lias, and to the species of the *foveolata*-group, of the Middle Lias; its resem-

blance to a typical *Eucyclus* or *Tectaria* readily serves to distinguish it.

Geological position.—Zones of *Am. angulatus* (2 exs.) and *A. Bucklandi* (7 exs.), Redcar.

Pleurotomaria undosa, *Deslongchamps.*

Pl. IX., fig. 1.

1847. 'Mém. Linn. Soc. Normandie,' vol. viii. t. xii. f. 2.

A Pleurotomaria from the Ironstone at Eston, in the cabinet of Mr. R. Oughton, justifies the insertion of this species in our catalogue. *P. undosa* is usually referred to *P. similis*, which, whilst having the general habit of that species, yet, by the broad, smooth area bounding the sutural band, is allied to *P. sulcosa*, this character being well exhibited by Deslongchamps's figure and Mr. Oughton's specimen, which removes it from *P. similis.*

Pleurotomaria rustica, *Deslongchamps.*

1844. 'Mém. Soc. Linn. de Normandie,' vol viii. t. 12, f. 1. p. 76.

I refer to this species the large, coarsely ornamented Pleurotomariæ found in the Cleveland Main Seam. The specimens which I have examined are all in too imperfect a state of preservation to permit of making any observations on this doubtful species. Its alliance with *P. similis* is obvious, but whether it be different or an aged form of that species, I am not prepared to say.

The largest examples measured between 3½ to 4 inches in the diameter of the base.

Geological position.—Zone of *Am. spinatus* (Cleveland Main Seam), Eston, Upleatham, Hob Hill, Belman.

Pleurotomaria concava, *Martin.*

Pl. IX., fig. 27.

1860. 'Paléontologie de la Côte-d'Or,' t. ii. f. 1, 2, p. 74.

Geological position.—Zone of *Am. planorbis* (Pleuromya limestone), High Thornborough, Northallerton (a cast).

Zone of *Am. Bucklandi*, Redcar (4 exs.).

Genus Discohelix, *Dunker*, 1848.

The genus *Discohelix* was instituted by Dunker for the depressed *Euomphali* of the Mesozoic rocks, and includes the Jurassic species referred to *Euomphalus* by Goldfuss, to *Straparolus* by D'Orbigny, and part to *Planorbis*, *Adeorbis*, and *Solarium* by other authors.

The alliance with the palæozoic genus *Euomphalus* is obvious;

indeed the chief distinction appears to be that of derivation; and if we rigidly adhere to the characters given by Dunker, then some species should be transferred to *Euomphalus*, and certain carboniferous Euomphali placed under *Discohelix*. The characters of the group are: shell depressed, more or less disk-shaped, flat or concave above, deeply umbilicated; whorls numerous, more or less four-sided, compact and narrow; peristome entire, outer lip thin. Operculum unknown.

Discohelix Oppeli, *Martin*.

Pl. X., fig. 8, *a*, *b*.

1860. (*Straparolus*.) 'Pal. de la Côte-d'Or,' t. i. fs. 39–43, p. 74.

Some of our specimens have a whorl more than the French types, and are proportionately larger; the whole upper surface is radially striated; the last whorl is increasingly deflected below the level of the upper ones, and is carinated only on the under side. Diameter of largest specimen $\frac{5}{16}$ths of an inch.

Geological position.—Zone of *Am. Bucklandi* (lower beds), Redcar.

Discohelix liasinus, *Dunker*.

1847. (*Planorbis*.) 'Palæontographica,' vol. i. t. xiii. fig. 20, p. 107.

Geological position.—Zone of *Am. planorbis*, Foxton.

Discohelix striatus, *Piette*.

Pl. IX., figs. 8, 9.

1856. (*Solarium*.) 'Bull. Soc. Géol. France,' vol. xiii. t. x. f. 10, p. 205.

Syn. 1865. *Solarium depressum*. Terquem and Piette. 'Lias de l'Est de la France,' t. ii. fs. 35–38.

The Yorkshire examples of this species exhibit some variation in the degree of flatness of the spire, height of the body-whorl, and in the character of the ornamentation, whilst many agree with Piette's figure, in having the upper and lower margins of the squarish whorls covered with tubercles; yet a few specimens present instead narrow costæ on the upper surface, which pass over the back as thick folds.

Geological position.—Zones of *Am. Bucklandi* (lower part) and *A. angulatus* (upper part), Redcar.

Discohelix aratus, *Tate*.

Pl. IX., fig. 5, *a*.

1870. (*Straparolus*.) 'Quart. Journ. Geol. Soc.' vol. xxvi. t. xxvi. f. 21, p. 404.

The types of this species prove now to be immature examples,

as some of our Yorkshire specimens have twice their diameter. With the increase of size, the thick and distant flexuous ribs of the young become slender and numerous in the adult. Dimensions: breadth, $\frac{1}{4}$ inch; thickness, $\frac{3}{20}$ inch.

Geological position.—Zone of *Am. margaritatus* (upper beds), Marske Mill, Saltburn, Huntcliff, Staithes (abundant).

Discohelix bellulus, *Tate.*

1870. (*Straparolus*), *loc. cit.* p. 404, t. xxvi. f. 22.

Ten examples associated with the last at Marske Mill.

Discohelix semiclausus, *Spec. nov.*

Pl. IX., fig. 14, *a.*

Shell small, globulose; spire sunk, base convex, umbilicus narrow, not exposing the inner whorls; whorls, 4, convex, embracing, ornamented with numerous fine, flexuous threads.

This species has some resemblance to *D. aratus*, but differs in its shape and finer ornamentation. Dimensions: diameter and height $\frac{1}{10}$ inch.

Geological position.—Zone of *Am. angulatus*, Redcar (4 exs.).

Euomphalus minutus, *Schübler.*

1870. Zieten. 'Verstein. Würtembergs,' t. xxxiii. f. 6.
1869. Brauns. 'Mittlere Jura,' t. ii. fs. 11–13, p 183.
Syn. 1850. *Straparolus minutus.* D'Orbigny.' 'Prod. I.' p. 248.
1855. *Natica neglecta.* Simpson. 'Foss. Y. L.' p. 104.
?1871. *Natica pilula.* Tate. 'Geol. Mag.' vol. viii. p. 5.

All the Yorkshire examples have an exserted spire, and agree with Brauns's representation of Schübler's species; but the shells to which I gave the name of *Natica pilula* have the spire flat, or very slightly concave. Both forms, however, agree in general shape, and in being ornamented with fine, longitudinal threads. Simpson describes his species as "having nearly the same characters as *Turbo buccinoides*, Y. and B., but quite smooth." This latter character, though it belongs to the cast, is incorrect as applied to the test.

Geological position.—In great profusion in the limestone-doggers in the Jet Rock, Runswick, Hawsker, Staithes, Scugdale.

Trochus Robigus, *Spec. nov.*

Pl. X., fig. 3, *a, b.*

Shell conical, whorls seven, angular; surface shining, and ornamented by flexuous striæ; base imperforate, convex.

The medial elongation of the whorls distinguishes this species

from the liassic species of the genus or of *Turbo*. Dimensions: length, $\frac{3}{10}$ths; diameter of base, $\frac{1}{8}$th inch.

Geological position.—Zone of *Am. oxynotus*, in the region of *A. raricostatus*, Robin Hood's Bay (2 exs.).

Trochus Thetis, *Münster*.

1842. In Goldfuss. 'Petref.' t. clxxix. f. 10, p. 34.

Pyritous casts of the shells of this species are common in the lower beds of the Middle Lias on the coast, but the test has been obtained from a few inland stations.

Geological position.—Zone of *Am. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Wood End, Ayton; Chop Gate, Bilsdale.

Trochus redcarensis, *Spec. nov*.

Pl. X., fig. 14.

Shell conical, higher than broad, composed of six subconvex, angulated whorls, separated by a channelled suture; upper surface ornamented with about thirty oblique costæ, which terminate in a subspinous tubercle on the posterior keel; tessellated by two longitudinal threads symmetrically placed between the keel and the suture. Last whorl biangulated; the oblique costæ are continued on to the anterior carina, there rising into tubercles, whence they proceed over the base as radial threads. Base flat, imperforate, ornamented by six concentric ribs, alternately slender and stout, and by the radial threads. Dimensions: height, $\frac{7}{32}$; diameter of base, $\frac{6}{32}$nds of an inch.

The Liassic Trochi, with biangulated whorls and transverse costations, include *T. Thetis*, Goldf.; *T. Perinianus*, D'Orb.; *T. geometricus*, Dumort.; *T. Doris*, Goldf., with which the present species has some affinity. It agrees with *T. Perinianus* in form, and with *T. Thetis* in its deeply-channelled suture. In *T. geometricus* the whorls are flat, and its form is narrow, whilst the subimbricating whorls of *T. Redcarensis* still further distinguish the two.

Geological position.—Middle part of the *Bucklandi*-Zone, Redcar.

Phasianella Morencyana, *Piette*.

Pl. IX., fig. 21.

1856. 'Bull. Soc. Géol. France,' vol. xiii. p. 204, t. x. f. 12.
1865. Terquem and Piette. 'Lias Inf. de l'Est de France,' t. iv. fs. 9-11.

Geological position.—Zones of *Am. angulatus*, Cliff (common), Redcar; and *Am. Bucklandi*, Redcar and Marske Bay (not common).

Pitonillus sordidus, *Spec. nov.*

Pl. X., fig. 19.

Shell small, conical, rather depressed, imperforate; whorls, five, convex, smooth, or obsoletely striated; similar to *P. conicus*, D'Orb., but with more inflated whorls. Dimensions: length $\frac{7}{24}$ths; diameter of base, $\frac{6}{32}$nds of an inch.

Geological position.—Zones of *Am. angulatus*, Redcar; and *A. Bucklandi*, Redcar and Marske Bay (15 exs.).

Turbo solarium, *Piette.*

Pl. IX., fig. 16.

1856. 'Bull. Soc. Géol. France,' vol. xiii. p. 205, t. x. f. 16.
1867. Terquem and Piette, *loc. cit.* t. iii. fs. 22–24.
Syn. 1867. *Turbo tiro.* Dumortier. 'Dép. Jur.' vol. ii. p. 191; t. 45, fs. 7, 8.
1867. *Turbo Burtoni.* Tate. 'Quart. Jour. Geol. Soc.' vol. xxiii. p. 314.

This species exhibits some variation in the minuter characters, though its general form is pretty constant. The type is a rotund, depressed shell, with smooth whorls, the posterior ones being angulated; mouth round, and the umbilicus small. Another form represented by Dumortier's figures has rounded whorls, and is imperforate. A third variety, typified by *T. Burtoni* (mihi), is with or without an umbilicus, and the surface of the whorls is finely, longitudinally striated. The common variety in the Yorkshire Lias agrees with *T. tiro*, Dumortier.

Geological position.—Zones of *Am. angulatus*, Millington (1 ex.), Redcar (2 exs.); and *Am. Bucklandi*, lower and middle regions, at Redcar (abundant).

Turbo latilabrus, *Stoliczka.*

Pl. IX., fig. 15.

1861. 'Sitz. d. K. Akad. d. Wissen. Wien,' vol. xliii. t. ii. f. 9, p. 173.

This species resembles the last, from which it differs in its more convex and narrower whorls, characters which remove it from *T. bullatus*, Moore, with which it has some affinity.

Geological position.—Main seam of ironstone (*Am. spinatus*-Zone), Eston and Upleatham Mines.

Turbo lineatus, *Moore.*

Pl. IX., fig. 20.

1867. 'Mid. and Up. Lias, S.W. of England,' p. 95, t. vi. fs. 13, 14.

Resembles the last, but is striated all over.

Geological position.—Main seam of ironstone, Upleatham (1 ex.).

Turbo reticulatus, *Moore.*

1867. 'Quart. Jour. Geol. Soc.' vol. xxiii. p. 556; t. xvi. fs. 11, 12.

My specimen from the Bucklandi-beds at Redcar agrees with the above-quoted figures and description, and, moreover, supplies a desideratum. The base is convex, with numerous acute ribs, radially striated, and is narrowly umbilicated.

Turbo Wilsoni, *Spec. nov.*

Pl. X., fig. 5.

Shell subglobose; spire very short, composed of five whorls, the last one considerably larger than the rest of the spire; ornamented with very fine, longitudinal costæ, and evanescent transverse plications at the suture. Base convex, umbilicated, covered with numerous concentric threads; aperture rotund.

Named after Dr. Wilson, F.G.S., my genial companion of many geological excursions.

Geological position.—Zone of *Am. Bucklandi*, Redcar (4 exs.).

Turbo cyclostoma, *Benz.*

Pl. IX., figs. 19, 20.

1833. In Zieten's 'Verst. Würtembergs,' t. xxxiii. f. 4.

Geological position.—Zones of *Am. margaritatus*, Staithes, an elongated variety, approaching to *T. Leo*, D'Orb.; *Am. spinatus*, rare in the main seam of ironstone at Eston, Upleatham, and Skinningrove Mines, and not uncommon in the outlying dogger-bands at Kettleness and Hawsker; *Am. annulatus*, Glaizedale (a cast).

Turbo aciculus, *Stoliczka.*

Pl. IX., fig. 22.

1861. *Trochus aciculus, loc. cit.* t. ii. f. 8, p. 173.

Referred with some doubt to the Hierlatz-shell, but differing from *Pitonillus turbinatus*, Moore.

Geological position.—Zones of *Am. spinatus*, one of the common shells of the main seam of ironstone, Eston, Upleatham, and Hob Hill Mines; *Am. annulatus*, Hob Hill (a cast).

Turbo Philemon, *D'Orbigny.*

Pl. IX., fig. 25.

1850. 'Prodromus,' vol. i. p. 214.
1853. 'Pal Fr. Terr. Jur.' t. cccxxvi. fs. 2, 3, p. 327.
Syn. 1870. *Solarium Thomsoni*, Tate, 'Irish Liassic Foss.' t. i. f. 9, p. 16.

Shell depressed, wider than high, of a Rotella-like aspect;

whorls 4, subquadrate, smooth, and shining; last whorl bicarinated, obtusely or squarely so; surface sometimes wrinkled or striated transversely, and rarely are the apical whorls longitudinally striated; base slightly convex; umbilicus narrow, its margin wrinkled. Dimensions: breadth, $\frac{1}{6}$th; height, $\frac{1}{10}$th of an inch.

Geological position.—Zones of *Am. angulatus* (3 exs.), and *A. Bucklandi*, Redcar (numerous examples).

Turbo tenuis, *Terquem and Piette.*

1865. 'Lias inf. de l'Est de la France,' t. iv. fs. 1–3, p. 52.

Geological position.—Abundant in the *Pleuromya*-limestones of the *A. planorbis*-zone, near Northallerton and Foxton.

Rissoa nana, *Martin.*

Pl. IX., fig. 17.

1860. *Turbo nanus.* 'Mém. Soc. Géol. Fr.' t. i. fs. 26, 27, p. 72.

The Redcar examples have the transverse costæ crossed by numerous fine threads—a detail not noted by the original describer.

Geological position. — Zone of *Am. Bucklandi*, lower part, Redcar.

Hydrobia solidula, *Dunker.*

Pl. IX., fig. 6.

1847. *Paludina solidula, loc. cit.* t. xiii. f. 9, p. 108.
Syn. 1855. *Turbo exemptus.* Simpson. 'Foss. York. Lias,' p. 104.

Geological position.—Zones of *Am. oxynotus*, Robin Hood's Bay (many examples); *Am. armatus*, Warter (a fragment of this or an allied species).

Genus Eucyclus, *Deslongchamps.*

The genus was founded by Deslongchamps ('Bull. Soc. Linn. de Normandie,' vol. v., 1860) to include certain *Littorina*-like shells, many of which had been located under *Purpurina*, *Turbo*, and *Trochus*, having a more or less elongated spire, thin test, and longitudinal ornament; generally granulated, tuberculated, or spinous costæ. The group was recognised by Morris and Lycett ('Mollusca Great Ool.,' 1854), but was insufficiently characterised, though the name *Amberleya* was imposed by them. Subsequently diagnostic characters were given by Lycett ('Supplt. G. Ool. Moll.,' 1863), but three years after the publication of Deslongchamps's name. The species are numerous in the Jurassic rocks.

Eucylus elegans, *Münster.*

Pl. IX., fig. 30.

1844. *Turbo elegans*, in Goldfuss, 'Petref. German.' t. cxciii. f. 10, p. 94.

Shell turbinate, conical, imperforate; whorls 7 to 9, convex, ornamented with two strong median ribs, posterior to which are one or two small ribs, raised into granulations by the transverse ribs that cover the whole whorl. Beneath the keel and adjacent to the anterior suture is a moderately-strong rib; apical whorls triangulated, tessellated by distant and prominent transverse threads.

Geological position.—Zones of *Am. angulatus*, Cliff (common), Redcar; and *A. Bucklandi*, Redcar (not uncommon).

Eucyclus Chapuisi, *Terquem and Piette.*

Pl. IX., fig. 29.

1865. *Trochus Chapuisi, loc cit.* t. ii. fs. 25-27, p. 43.

Whorls angulated, sub-imbricating, with granular ribs.

Geological position.—Zone of *Am. Bucklandi*, Redcar (4 exs.).

Eucyclus selectus, *Chapuis and Dewalque.*

1854. *Turbo selectus*, 'Foss. du Luxembourg,' t. xii. f. 7, p. 89.

Whorls imbricating, 3 rows of granules; length one inch.

Geological position.—Zone of *Am. Bucklandi*, Marske Bay (1 ex.).

Eucyclus acuminatus, *Chapuis and Dewalque.*

Pl. X., fig. 20.

1854. *Trochus acuminatus*, 'Foss. du Luxembourg,' t. xii. f. 3. p. 82.

Geological position.—Zone of *Am. angulatus*, Redcar.

Eucyclus imbricatus, *Sowerby.*

1821. *Trochus imbricatus*, 'Min. Con.' t. cclxxii. figs. 5 and 6.
Syn. 1855. *Turbo concinnus.* Simpson. 'Foss. York. Lias,' p. 104.

Specimens of *T. concinnus* in the Whitby Museum are casts probably of this or an allied species.

Geological position.—Zones of *Am. armatus*, Robin Hood's Bay, Huntcliff, Coatham Scars, Chop Gate, Bilsdale.

Eucyclus Guadryanus, *D'Orbigny.*

1853. (*Trochus.*) D'Orbigny, 'Pal. Fr. Terr. Jur.' t. cccxi. fs. 4–7, p. 268.

More slender than *E. imbricatus*, with about three rows of large granules.

Geological position.—Zone of *Am. Jamesoni*, Huntcliff (2 exs., imperfect).

Eucyclus undulatus, *Phillips.*

Pl. X., fig. 12.

1829. *Turbo undulatus*, 'Geol. York.' t. xiii. f. 8.
1855. Simpson, *loc. cit.* p. 104.
Syn. 1850. *Turbo subundulatus*, D'Orbigny, 'Prod. I.' p. 228.
1855. *Turbo adductus et T. rugosus.* Simpson, *loc. cit.* p. 104.

Shell pyramidal; whorls 6 to 7, angular, sub-imbricating, flat above; ornamented by about 10 granular, longitudinal ribs, crossed by strong striæ; last whorl angular, carinated, and tuberculose, concentrically costated; base very convex, concentrically costated, and transversely striated; aperture large, subangular; columella straight and imperforate. Dimensions: length, 1½ inches; diameter of last whorl, 1 inch.

The type-specimen in the York Museum is a cast, showing a weak carina, and traces of numerous longitudinal lines and faint transverse wrinkles on the upper part of the whorls. The species is allied to *E. imbricatus*, Sow., but differs by its robust shape, less angular whorls, and its more numerous rows of granulations and coarser transverse striæ. It is confined to the North of Yorkshire.

Geological position.—Zones of *Am. capricornus*, Staithes, Hummersea, Huntcliff (common); *Am. margaritatus*, Staithes, Rockcliff, Hawsker (rare); *A. spinatus*, Upleatham (one ex., perhaps a variety).

Eucyclus Nireus, *D'Orbigny.*

1854. *Turbo Nireus*, 'Pal. Fr. Terr. Jurass.' t. cccxxvii. fs. 11–13. p. 333.

Geological position.—Zone of *Ammonites spinatus.* Main seam of ironstone, Hob Hill Mines (1 ex.).

Eucyclus couspersus, *Spec. nov.*

Pl. X., fig. 11, *a*, *b*.

Shell turriculated, imperforate; whorls 7, angular, imbricating, suture channelled; upper part of penultimate whorl with 8 longitudinal rows of small granules, crossed by transverse striæ; keel granulated, situated in the anterior third of the whorl, beneath which are about 4 longitudinal threads; base

convex, with 15 concentric ribs, obsoletely granulose, and radiating lines; aperture moderately angulated. Dimensions: lengh, $\frac{9}{16}$ths; diameter of base, $\frac{6}{16}$ths of an inch.

This species resembles *E. Julia*, D'Orb., in its subturreted form and general ornamentation, but differs in its granulated keel, and numerous longitudinal costæ, and is not half the size.

Geological position.—Main seam of ironstone (Zone of *A. spinatus*), Eston (1 ex.).

Eucyclus cingendus, *Spec. nov.*

Pl. X., fig. 15.

Shell conical; whorls 7, rotund; penultimate, with about 10 thick, depressed longitudinal costæ, transversely striated; base similarly ornamented; moderately umbilicated in the young, and with a narrow umbilical fissure in the adult. Dimensions: length, $1\frac{1}{12}$th inch; diameter of last whorl, $\frac{6}{10}$ths inch. Differs from *E. Nicias*, D'Orb., in its thick, depressed, and more numerous costæ.

Geological position.—Zones of *Am. spinatus*, main seam of ironstone, Upleatham and Eston Mines; *Am. margaritatus*, Staithes, Huntcliff; *Am. annulatus*, Hob Hill (a cast); and top of *A. capricornus*, Huntcliff (1 ex.).

Littorina clevelandica, *Spec. nov.*

Pl. X., fig. 17.

Shell ovately conical, of 4 convex whorls, longitudinally 5 costated, and rugosely striated transversely, imperforate; aperture oval.

The penultimate whorl is obtusely bicarinated by two thick sub-acute costæ, the superior of which is medial; a third, and similar one, is adjacent to the anterior suture; above the median rib are two granulated and smaller costæ; the whole surface of the shell traversed by rugose striæ, forming denticulations or granulations on the two posterior ribs, and crenulations on the others. The interspaces on the body-whorl are sometimes occupied by a row of small granules or a slender rib; base with 12 concentric ribs, and radial striæ. Dimensions: height, $\frac{8}{12}$ths; diameter of last whorl, $\frac{7}{12}$ths of an inch.

Geological position.—Lower *Margaritatus* beds, Huntcliff, Hummersea, Rockcliff, and Staithes.

Littorina semiornata, *Münster.*

1844. *Turbo semiornatus*, in Goldfuss, 'Petref.' t. cxciii. f. 8. p. 94.

Two casts from the *Angulatus*-beds at Redcar may belong to shells of this species.

Natica buccinoides, *Young and Bird.*

Pl. IX., fig. 11.

1828. *Ampullaria buccinoides*, 'Sur. York. Coast,' p. 249.
1855. *Turbo buccinoides*. Simpson. 'Foss. York. Lias,' p. 104.
Syn. 1850. *Natica Pelops*. D'Orbigny. 'Prod. I.' p. 247, and 1853, 'Pal. Fr.' t. cclxxxviii. fs. 16,17.

There cannot be any doubt of the identity of *Ampullaria buccinoides* with *Natica Pelops:* Oppel ('Juraf.,' p. 258) recorded the species under D'Orbigny's name from the Upper Lias of Yorkshire. I think that Young and Bird's description, or rather comparison with their *A. Sigaretina*, t. 284, f. 3, will justify the adoption of their name.

The original reads:—"Another shell of this kind occurs in the lias bands; its spire is more prominent [than in *A. Sigaretina*], and each whorl is flattened on the upper part, as in the spire of *Buccinum glaucum*."

Shell ovate; spire depressed; whorls 5 to 6 convex, slightly flattened at the posterior suture, marked with fine, but faint, longitudinal striæ, finely punctured (Simpson), and fine lines of growth. Last whorl large; base convex; aperture oval. Length about $1\frac{1}{4}$ inch.

Geological position.—Zone of *Ammonites serpentinus*, Runswick.

Natica purpuroidea, *Spec. nov.*

Pl. X., fig. 13.

Specimen imperfect, and somewhat eroded; it is evidently congeneric with *Ampullaria angulata*, Dunker, quoted by Brauns under *Purpurina*, and I have no doubt of its distinctness from any figured liassic gasteropod.

Shell ovately globose, pyriform; spire oblique; whorls few; body-whorl angulated medially, posterior-half concave, anterior part convex, surface covered with flexuous lines, and rugose of growth. Length, $1\frac{7}{12}$ths inch; greatest breadth, $1\frac{1}{12}$th inch.

Geological position.—Not ascertained, probably *A. Bucklandi*-beds, Redcar.

Turritella Zenkeni, *Dunker.*

1847. *Melania Zenkeni*, 'Palæontographica,' vol. i. p. 108, t. xiii. fs. 1-3.

Geological position.—Zone of *Am. Bucklandi*, Marske Bay and Redcar (7 exs.).

If *T. Deshayesea* be distinct from *T. Zenkeni*, then must it be added to our list, as one specimen closely approaches to the figured specimen in size. It measures $2\frac{1}{4}$ inches long, body-whorl $\frac{3}{4}$ inch diameter, and there are 9 whorls.

Turritella Dunkeri, *Terquem.*

Pl. IX., fig. 3.

1854. 'Pal. de Hettange,' t. xiv. f. 5 and xvi. f. 16, p. 252.
Syn. 1855. *Defossa.* Simpson. 'Foss. York. Lias,' p. 104.

The specimens united under this name exhibit great variation of shape and ornament of the whorls, and of size. The type has rounded or sub-angular whorls with 5 longitudinal costæ, transversely striated. The whorls vary in the amount of angularity and in the number and strength of the ribs and transverse striations, the apical whorls of some specimens have open cancellations. Our longest example measures 1 inch, and has 14 whorls.

Geological position.—Zones of *Am. angulatus*, Cliff; *A. Bucklandi*, Redcar; and *A. oxynotus*, Robin Hood's Bay (a few exs.).

Turritella regularis, *Terquem and Piette.*

1865. (*Cerithium.*) 'L. Lias de l'Est de la France,' t. vi., fs. 12, 13, p. 65.

A small shell from the *Oxynotus*-beds, Robin Hood's Bay, with flat, disjointed whorls, ornamented with 5 rows of granulations, and transversely striated, though having more costæ than are shown in Terquem and Piette's figures, yet probably belongs thereto. Somewhat similar specimens from the *Bucklandi*-beds at Redcar may be of the same species. They are Turritellas. The authors of the species were uncertain of its generic position; it cannot well be associated with *T. Dunkeri.*

Cerithium gratum, *Terquem.*

1855. 'Pal. de Hettange,' t. xvii. f. 6, p. 277.

Geological position.—Zones of *Am. angulatus* and *A. Bucklandi*, Redcar.

Cerithium semele, *D'Orbigny.*

1850. 'Prodromus I.' p. 215.
1860. Martin. 'Pal. de la Côte-d'Or,' t. xi. fs. 8–10.

Geological position.—Zones of *Am. angulatus*, Cliff; *A. Bucklandi*, Redcar.

Cerithium spiratum, *Moore.*

1867. 'Quart. Journ. Geol. Soc.' vol. xxiii. t. xiv. f. 12, p. 543.

Geological position.—Zone of *Am. angulatus*, Redcar.

Cerithium Slatteri, *Tate.*

1870. 'Quart. Journ. Geol. Soc.' vol. xxvi. t. xxvi. f. 7, p. 406.
Syn. 1829? *Rostellaria? sp.* Phillips. 'Geol. York.' t. xii. f. 12.
1855? *Turbo aureus.* Simpson. 'Foss. York. Lias,' p. 104.

Simpson's species is founded on pyritous casts, and seems to include *C. Slatteri* and *Chemnitzia Blainvillei*, and Phillips's *Rostellaria* is one or the other of them.

Geological position.—Zone of *Am. Jamesoni*, Huntcliff, Upsall; common in the region of *A. armatus*, Robin Hood's Bay.

Cerithium liassicum, *Moore.*

Pl. IX., fig. 18.

1867. 'Mid. and Up. Lias, S. W. England,' t. iv. fs. 16, 17, p. 85.

Geological position.—Zones of *Am. spinatus*, Hawsker, main seam of ironstone Eston and Upleatham Mines; and *A. annulatus*, Hob Hill, Grosmont, and Glaizedale.

Cerithium acriculum, *Spec. nov.*

Pl. X., fig. 1.

Shell turreted, the length 3 times the width; whorls 8 in a length of $\frac{3}{20}$ths of an inch, angulated and imbricating; surface of whorls transversely wrinkled and striated. Differs from *C. Ibex* (*mihi*), in the absence of a longitudinal band at the posterior suture.

Geological position.—Zone of *Am. spinatus*, Hawsker (1 ex.).

Cerithium quadrilineatum, *Römer.*

1836. (*Turritella.*) 'Ool. Gebirge,' p. 154, t. xi. f. 14.
1869. Brauns. 'Mit. Jura,' t. ii. fs. 7, 8.

Geological position.—Highest beds of Alum shale; Lofthouse Alum Works; also in the Blea Wyke Beds.

Cerithium armatum, *Goldfuss.*

1843. 'Petref. Germanica,' t. clxxiii. p. 31.

Geological position.—Zone of *Am. jurensis*, Peak (2 exs.).

Chemnitzia Collenoti, *Terquem and Piette.*

1865. *Cerithium Collenoti*, 'Lias inf. de l'Est de France,' p. 63, t. vi. fs. 1, 2.

My specimens referred to the above species differ from the figure of Terquem and Piette in the costæ, which are irregular,

short, and thick, being confined to the upper whorls, the body-whorl being wrinkled or striated transversely.

Geological position.—Zones of *Am. Bucklandi*, Redcar; *A. oxynotus*, Robin Hood's Bay (1 ex. Whitby Mus.).

Chemnitzia transversa, *Blake.*

Pl. X., fig. 21.

1872. *Cerithium transversum*, 'Quart. Jour. Geol. Soc.' vol. xxviii. p. 142.

Shell conical, whorls 9 convex, ornamented by thick and straight transverse plications, 10 on the body-whorl; the first four apical whorls without ornament; whole surface smooth; base convex, smooth; umbilicus minute. Dimensions: total length, ⅛th inch.

This species differs from its congeners, and its nearest ally, *C. Etalense*, in the absence of striations, and in having a minute umbilicus.

Geological position.—Zone of *Am. angulatus.* Cliff (1 ex.).

Chemnitzia Berthaudi, *Dumortier.*

1867. 'Dép. Jurass.' vol. ii. p. 184, t. xliv. f. 2.
Syn. 1867. *Chemnitzia Tylori.* Tate, 'Quart. Jour. Geol. Soc.' vol. xx. p. 313.

Geological position.—Zone of *Am. Bucklandi.* Redcar.

Chemnitzia unicingulata, *Terquem.*

1853. *Melania unicingulata*, 'Pal. de Hettange,' t. xiv. f. 10, p. 256.

Geological position.—Zones of *Am. angulatus*, Cliff (1 ex.); and *Am. Bucklandi*, Marske Bay (1 ex.).

Chemnitzia Youngi, *Simpson.*

Pl. XVI., fig. 6.

1855. *Scalaria ? Youngi.* 'Foss. York. Lias,' p. 104.

"Length, 1¼ inch.; 18 rather tumid whorls; 26 to 28 obtuse ribs, curving to the right; faintly longitudinally striated, more distinct near the well-defined suture; length, five times the width."—Simpson.

This handsome species is easily recognised by its inflated whorls and strongly-arched costæ.

Geological position.—Zone of *Am. armatus*, Robin Hood's Bay (Whitby Mus.).

Chemnitzia carusensis, *D'Orbigny.*

1850. 'Prod. I.' p. 226; 'Pal. Fr. Terr. Jur.' t. cccxxvii. fs. 13–15, p. 34.

Geological position.—Zones of *Am. armatus*, Robin Hood's Bay (2 exs.); *A. Jamesoni*, Huntcliff.

Chemnitzia undulata, *Bens.*

1832. *Turritella undulata.* In Zieten's 'Verst. Würt.' t. xxxii. f. 2.

Geological position.—Unknown. Robin Hood's Bay (one example in Collection of Mr. Leckenby submitted to me).

Chemnitzia Blainvillei, *Münster.*

1834. *Melania Blainvillei.* In Goldfuss, 'Petref. Germ.' t. xcviii. f. 9, p. 112.

Geological position.—Zones of *Am. Jamesoni*, Huntcliff, Upsall; *A. capricornus*, Huntcliff; *Am. margaritatus*, Huntcliff, Staithes; *Am. spinatus*, Hob Hill (2 exs.); Hawsker, Kettleness; *Am. annulatus*, Hob Hill (4 exs.), Hutton, Glaizedale, Bransdale.

Chemnitzia foveolata, *Spec. nov.*

Pl. IX., fig. 12.

Shell conical, elongated; whorls 12, nearly flat or slightly convex, separated by a narrow, but well-defined suture; upper whorls ornamented by a great number of slightly-arched ribs, limited by a longitudinal band at each suture; the anterior whorls with thicker costæ, but separated into granular nodulations by transverse sulci.

It is very distinct from *C. Blainvillei* and its other congeners.

Geological position.—Zone of *A. Jamesoni*, Wood End Railway Cutting, near Ayton.

Chemnitzia semitecta, *Tate.*

Pl. IX., fig. 23.

1867. *Cerithium sublineatum.* Moore. 'Mid. and Up. Lias,' t. iv. f. 11. p. 84 (non *Chemnitzia sublineata*, D'Orbigny, 1850).

I am dubious as to this identification, but the shell, which is figured, though having some affinity with *C. Blainvillei*, appears distinct by its shape, obsolete plications on the last whorl, and the absence of concentric costæ on the base. It is a smaller shell than *C. sublineata*, Moore, with more convex whorls, but with the same ornament, and may be the same.

Geological position. — Zones of *A. margaritatus*, Staithes (3 exs.); *A. spinatus*, Eston and Upleatham (4 exs.). Moore's specimen is from the Upper Lias.

Chemnitzia nuda, *Münster.*

Pl. X., fig. 9.

1843. *Turritella nuda.* Münster. Goldfuss, t. cxcvi. f. 13, p. 106.

Geological position.—Zones of *Am. margaritatus* (lower part), Huntcliff; ? *A. spinatus*, Upleatham and Eston Mines (3 exs.).

Chemnitzia citharella, *Spec. nov.*

Pl. X., fig. 4.

Syn. 1855. *Turbo ferreus.* Simpson. 'Foss. York. Lias,' p. 105.

Shell turriculate, apex acute; whorls 7 to 8, slightly convex, a very little "en gradins," with about 20 decurrent transverse costæ on the whorls of the spire, which become somewhat irregular plications on the body whorl. Upper whorls with numerous longitudinal threads traversing the costæ. Body whorl occupying nearly one-half the length of the shell; aperture oval. Dimensions: total length 1 inch; breadth of body whorl $\frac{5}{12}$ ths inch.

Turbo ferreus noticed by Simpson as a cast $\frac{3}{4}$ inch long, with 6 flattened whorls, may very probably belong here.

C. citharella is evidently congeneric with *C. phasianoides*, Deslong. and *C. Braunoviensis*, Dumort., and may therefore belong to *Littorinella*. It is intermediate in form between these two species, but the ornamentation is distinct.

Geological position.—Zone of *Am. margaritatus*, Straithes, Rockcliff, Huntcliff; top part of *A. capricornus*, Huntcliff.

Chemnitzia acula, *Spec. nov.*

Pl. X., fig. 10.

Shell cylindrical, elongated, whorls ten, sub-convex, shining; posterior suture bordered by a narrow band; whole surface, including the band, covered with fine transverse striæ. Dimensions: length, $\frac{3}{10}$ths inch; breadth, $\frac{1}{12}$th inch.

C. acula resembles *Melania amalthei*, Quenstedt, 'Jura' t. xxiv. fs. 6 to 8, but has more whorls and is much longer in proportion to the width; whilst *M. amalthei* is quite smooth, and probably belongs to *Hydrobia*.

Geological position.—Zone of *Am. annulatus*, Glaizedale (1 ex.). An imperfect specimen of a *Chemnitzia* with more inflated whorls and flexuous striæ may be an adult form of this species; it is from the same horizon at Staithes. Certain casts in the Grey-shales at Boosbeck may belong here.

Actæonina fragilis, *Dunker.*

1847. *Tornatella fragilis*, 'Palæontographica,' vol. i. p. 111, t. xiii. f. 9.

Zone of *Am. planorbis*, near Northallerton, and at Foxton.

Zone of *A. angulatus*, and *A. Bucklandi*, Redcar.
„ *A. oxynotus*. Robin Hood's Bay.

Actæonina sinemuriensis, *Martin*.

1860. *Actæon Sinemuriensis*, 'Pal. Côte-d'Or,' t. i. fs. 9, 10, p. 70.

Geological position.—Zone of *Am. Bucklandi*, Redcar.

Actæonina ilminsterensis, *Moore*.

Pl. IX. fig. 7.

1867. 'Up. and Mid. Lias, S. W. England,' p. 82, t. v. figs. 25–26.
Syn. 1867. *Actæon tessellatus*. Tate. 'Geol. Mag.' vol. viii. p. 6.

"Ovate elongated, whorls six, convex, bluntly keeled at the suture; last whorl ornamented with about 20 equi-distant longitudinal depressed costæ and perpendicularly striæ; the sulci and the costæ are of about equal width. Aperture oval. Total length, $\frac{1}{10}$ths of an inch. Differs from *A. Broliensis*, Bruguière, chiefly in its ovate form." Most of the Yorkshire specimens differ from the Gloucestershire and Somersetshire ones in the greater breadth of the sulci, and in consequence the surface is costated and not striated.

Geological position.—Zones of *A. capricornus*, Huntcliff, Staithes; *A. margaritatus*, Huntcliff, Marske Mill; *Ammonites spinatus*, Eston and Upleatham Mines; Hawsker (1 ex.); Grosmont (1 ex.); *A. annulatus* (a small cast), Hob Hill.

Actæonina marginata, *Simpson*.

1855. *Auricula ? marginata*, 'Foss. York. Lias,' p. 134.
Syn. 1829. *Actæon sp.* Phillips, 'Geol. York. Coast,' t. xiii. f. 11.
1870. *Tornatella capricorni*. Tate. 'Quart. Jour. Geol. Soc.' vol. xxvi. t. xxvi. f. 18, p. 405.

Shell elliptical, spire elongated, whorls 5, scalariform; shoulder of whorl forming a right-angle, obtusely rimmed; last whorl slightly impressed below the upper angle longitudinally, and marked with fine curved lines of growth; aperture oval, very acute behind and sub-angular in front; outer lip thin; columella with a longitudinal fold. Dimensions of Yorkshire example. Total length $\frac{3}{10}$ths, length of large whorl $\frac{2}{10}$ths, breadth $\frac{1}{8}$th inch. This species resembles *A. sinemuriensis*, but is more elliptical, and the striations are finer.

Geological position.—Zones of *Am. armatus*, Robin Hood's Bay (4 exs.); *Am. Jamesoni* and *A. capricornus*, Huntcliff (obscure examples).

Actæonina chrysalis, *Spec. nov.*

Pl. X., fig. 23.

Shell oblong ovate, whorls 5, sub-convex, depressed at the suture, with a single impressed line on the shoulder of the whorl, marked with transverse plications and fine striæ; spire elongated, subacute; aperture elongated, slightly effuse in front, posteriorly very narrow; base slightly depressed. Dimensions: total length $\frac{3}{4}$ inch; length of last whorl $\frac{1}{2}$ inch, breadth $\frac{5}{16}$ths inch.

Geological position.—Zone of *Am. spinatus*, Eston and Upleatham Mines (2 exs.).

Actæonina pulla, *Koch and Dunker.*

1837. 'Beiträge. Verst. Nordd. Oolith.' t. ii. f. 11, p. 33.
1850. Morris and Lycett. 'G. Oolite Moll.' t. xv. f. 4. p. 119.

Geological position.—Zone of *Am. jurensis*, Peak (1 ex.); also in the Inferior Oolite at the same place.

CLASS LAMELLIBRANCHIATA.

By RALPH TATE.

Young and Bird described and mentioned 32 species of Liassic conchifers; 6 of their specific names are adopted, whilst 14 represent 10 of Sowerby's species, these authors having imposed new names for several of the species described by Sowerby upon the most trivial grounds; 3 species, wrongly identified, have been described by subsequent authors, and the 8 species remaining cannot be satisfactorily established, so that 19 determinate species only are recorded in the first catalogue of Yorkshire liassic bivalves. Phillips (1829) refigured 3 of Young and Bird's species, and gave drawings of 10 new species, 2 of which, *Pholadomya obliquata* and *Corbis uniformis*, I erase from the nomenclature. He further records 23 species of Sowerby, and indicates the presence of 9 others, bringing up the total of this class to 50.

Williamson and Hunton published manuscript names of a few species, but whether of new or previously-described forms, it is impossible to say. Stutchbury (1843) described and figured *Cardinia concinna* from Robin Hood's Bay as a new species, calling it *C. lanceolata*.

In 1855 Oppel added 3 from personal observation, and in the same year Simpson published descriptions of no less than 124 species of Liassic lamellibranchs from the neighbourhood of Whitby. After a careful study of the types, I find that the 124 names have been given to only 65 species; 53 names I reject as being only in duplicate, and 4 as belonging to indeterminate specimens. Of the 65 satisfactory species, the majority have been described by other authors, whose names are adopted; whilst 14 only are here attributed to the local palæontologist.

In the third edition of 'Phillips's Geology of Yorkshire' three additional forms are recorded that are described in the following pages, and one, *Leda rostralis*, which we have not met with. The total number, excluding the last, reaches 77; while those recorded in these pages number 190. The greater bulk of our additions comes from the Lower Lias, from which 7 species only had been recorded previous to the publication of my coadjutor's paper on the Infra Lias in the southern part of the country.

Ostrea liassica, *Strickland*.

1845. In Murchison's 'Geol. of Cheltenham,' 2nd edit. p. 99.
1871. Phillips. 'Geol. Thames Valley,' t. vii. f. 47.
Syn. 1846. *Ostrea sublamellosa*. Dunker. 'Palæont.' i. t. vi. f. 41.

Brauns, who has carefully reviewed the liassic species of N. W.

Germany, possibly suppressing too many, has admitted two species of oysters which have generally been quoted under *O. irregularis*, Goldfuss; these are *O. sublamellosa*, Dk., and *O. ungula*, Münster. *O. irregularis* he regards as an attached modified form of *Gryphæa arcuata*. This course appears reasonable, but one correction is necessary. Strickland's *O. liassica* is the same shell as *O. sublamellosa*, described in the following words:—"Longitudinally oblong, slightly curved, imbricated; the upper valve flat, the under one somewhat rounded; margin entire;" and, having priority of publication, is the name to be employed.

Geological position.—Zone of *Am. planorbis*, Cliff, Hotham, Pocklington, Eston Gypsum Pit, neighbourhood of Northallerton. *Rhætic*, Howsham.

Ostrea ungula, *Münster.*

1833. 'Jahrbuch für Mineral.' p. 325.
Syn. 1858. *O. irregularis.* Quenstedt. 'Jura,' t. iii. f. 15, p. 45.

Geological position.—Zones of *Am. angulatus*, Redcar (lower beds), Slakes Pit, Coatham, Cliff; *Am. Bucklandi*, Redcar.

Ostrea Goldfussi, *Bronn.*

In 'Ersch. Grub. Encycl.' iii. sect. vii. p. 199.
Syn. 1834. *Ostrea læviuscula.* Münster, in 'Goldfuss Pet. Germ.' t. lxxix. f. 6, p. 20 (non Sow.).
1855. *Ostrea irregularis.* Terquem. 'Pal. de Hettange,' t. xiv. f. 2, p. 185.
1869. *Ostrea irregularis.* Dumortier. 'Dép. Jurass.' pt. ii. t. xlix. fs. 1–3.

Shell of a deltoid to circular form; upper valve slightly convex, wrinkled or striated concentrically; lower valve attached by whole surface; front margin elevated; about 2½ inches diameter.

Geological position.—Zones of *Am. Bucklandi*, Redcar, Marske Bay, Robin Hood's Bay; *A. oxynotus*, Robin Hood's Bay; *A. Jamesoni*, Robin Hood's Bay.

Ostrea semiplicata, *Münster.*

1834. Goldfuss. 'Petref. Germ.' t. lxxii. f. 7, p. 4.

This species resembles *Terquemia* (*? Hinnites*) *Heberti*, Tqm. and Piette, and with which it has been confounded.

Geological position.—Zones of *Am. angulatus*, Redcar, Millington; *Am. Bucklandi*, Redcar.

The Millington specimen is only a fragment, and may belong to *T. Heberti*, but a few perfect specimens have been gathered at Redcar.

Ostrea subauricularis, *D'Orbigny.*

1850. 'Prodromus I.' p. 257.
Syn. 1834. *Ostrea auricularis.* Münster in Goldfuss, 'Petref. Germ.' t. lxxix. f. 7 (non Walk.).

Geological position.—Upper part of Alum Shale, Lofthouse Alum-works, and Zone of *Am. Jurensis*, Peak.

Ostrea submargaritacea, *Brauns.*

1864. 'Palæont.' vol xiii. p. 101, t. xxiv. fs. 6, 7.

A large, depressed, beautifully-perlaceous oyster of an elliptical shape.

Geological position.—Zones of *Am. spinatus*, main seam of ironstone, Eston, Upleatham, Belman, and Challoner Mines, Staithes, Kettleness; *Am. margaritatus*, Grosmont.

Ostrea sportella, *Dumortier.*

1857. 'Mem. de la Soc. d'Agr. d'Hist. de Lyon,' t. i. fs. 1–8, p. 3 and 1869. 'Dép. Jur.' vol. iii. t. xxii. fs. 6, 7; and t. xli. fs. 3–7, pp. 144 and 316.

This species is a connecting link between the true oysters and those of the section Gryphæa; it is of a regular form, and plicated laterally, but has no beak, being attached by a considerable surface in the umbonal region.

Geological position.—Zone of *Am. spinatus*, Hob Hill Mines (a large typical example). Small shells of a similar form have been obtained from the Zones of *A. armatus*, Warter, and of *A. Jamesoni*, Peak, but they are probably young, broadly-attached examples of *Gryphæa obliquata.*

SECTION GRYPHÆA.

Eminently distinguished by the large, curved beak of the lower valve, which usually projects considerably above the upper one. They are generally of regular form, and they are free, or if adherent, only in the young stage, and then only by a point. However, intermediate stages are exhibited by individuals of species of *Ostrea* and *Gryphæa* belonging to several epochs; so that Gryphæa is degraded to the rank of a group or section of the genus *Ostrea*; nevertheless, it may be expedient to retain the name.

Ostrea arcuata, *Lamarck.*

1802. 'Système des Animaux s. vertèbres,' p. 398.
Syn. 1815. *Gryphæa incurva.* Sowerby. 'Min. Con.' t. cxii. fs. 1, 2.
1828. *Gryphæa incurva.* Young and Bird. 'Geol. Surv.' p. 242, t. viii. f. 13.
1855. *Gryphæa incurva.* Simpson. 'Foss. Y. L.' p. 107.

The specific identity of *Gryphæa arcuata* and *G. incurva* has

always been admitted, yet the older name has been rejected in this country for that given at a later date by an English author, a course in contravention of a universally-recognised law of priority that cannot too severely be censured.

Geological position.—Zones of *Am. angulatas*, Redcar; *A. Bucklandi*, Redcar, Robin Hood's Bay, Nunthorpe, Ellerbeck, and near Sigston; *A. oxynotus*, Robin Hood's Bay.

In the lower part of the *Angulatus*-series at Redcar *O. arcuata*, though abundant, is always dwarfed, and it is only in the highest beds that it acquires its normal size and shape. As in other districts, the *Bucklandi*-beds are the head quarters of this species, some of the limestones of which are made up of its shells. In the *Oxynotus*-series at Robin Hood's Bay *O. arcuata* does not constitute banks, as in the underlying series, but occurs sparsely scattered throughout, being somewhat rare in the region of *Ammonites raricostatus*.

Ostrea cymbium, *Lamarck.*

1819. 'Hist. Nat. des Animaux s. vertèbres,' vol. vi., p. 198.

VARIETY OBLIQUATA.

Syn. 1818. *Gryphæa obliquata.* Sowerby. 'Min. Con.' t. cxii. f. 3.
1834. *Gryphæa obliqua.* Goldfuss. 'Pet. Germ.' t. lxxxv. f. 2, p. 30.
1855. *Gryphæa M'Cullochi.* Simpson. 'Foss. Y. L.' p. 107.

This shell is sometimes mistaken for *G. arcuata*, but it is more lengthened anteriorly, and is, moreover, oblique.

Geological position.—Zones of *Ammonites oxynotus*, Robin Hood's Bay (rare); *A. armatus*, Robin Hood's Bay and Redcar; *A. Jamesoni*, in all the coast sections, and generally where this horizon is exposed.

This is one of the most abundant fossils in the lower part of the Middle Lias, but does not seem to have been gregarious, like its ally *O. arcuata*, or the related variety in the higher beds.

VARIETY DEPRESSA.

Syn. 1820. *Gryphites Gigas.* Schlotheim. 'Petrefact.' p. 286.
1829, 75. *Gryphæa Macullochii.* Sowerby. 'Min. Con.' t. dxlvii. fs. 1–3.
1829, 35, 75. *Gryphæa depressa.* Phillips. 'Geol. York.' t. xiv. f. 7.
1855. *Ostrea concinna, O. inflata, O. patellæformis,* and *O. tumidulosus, Gryphæa orbicularis.* Simpson. 'Foss. Y. L.' p. 107.

Phillips's figure represents the common oyster in the middle part of the Middle Lias, where it forms thick beds, traceable over a large area. It does not merit notice as a modified form of the large and thick variety of *O. cymbium*, though it is usually flatter than it, yet when met with isolated, it is undistinguishable.

O. concinna, Simpson, I regard as a cast of the flat valve of *G. depressa*, Phil., as I do his *O. inflata* and *O. patellæformis* as casts

of young examples of *O. cymbium*, and his *O. tumidulosus* the cast of an adult shell referable to the same.

Typical examples of *O. cymbium* have not been observed by me.

Geological position.—Zones of *Am. capricornus* (upper part), on the coast, Guisbro', Kirkleatham; *A. margaritatus*, on the coast, Hutton, Roseberry, Bilsdale, Danbydale, &c.

Anomia striatula, *Oppel.*

1856. 'Die Juraformation,' p. 107.
1867. Terquem and Piette. 'Lias Inf. de l'Est de France,' t. xiv. f. 5. p. 113.

Geological position.—Zone of *Am. angulatus*, Millington.

Anomia alpina, *Winkler.*

1859. 'Schichten der avicula contorta,' p. 5, t. i. fs. 1, 2.
Syn. 1855. *Anomia pellucida.* Terquem. 'Pal. de Hettange,' p. 112, t. xxv. f. 5 (non Müller).

Geological position.—Zone of *Am. angulatus*, Millington (1 ex.).

Anomia numismalis, *Quenstedt.*

1856. 'Der Jura,' p. 311, t. xlii. f. 9.

Geological position.—Zones of *Am. armatus*, Robin Hood's Bay; *A. Jamesoni*, Coatham; *A. capricornus*, Huntcliff; *A. margaritatus*, Huntcliff; *A. spinatus*, Upleatham.

Pecten lunularis, *Römer.*

1839. 'Verst. Nord. d. Ool. Nachtrag,' p. 26.
Syn. 1828. *P. (cf.) lamellosus* (Sow.). Young and Bird, p. 235.
1845. *P. liasinus*, Nyst. Dunker, Oppel, &c.
1855. *P. pulchellus, planus.* Simpson. 'Foss. Y. L.' pp. 108, 109.

Young and Bird evidently allude to this species in describing a lenticular and circular Pecten, nearly smooth, or faintly striated; not unlike *P. lamellosus*, Sow., but flatter and smoother. The largest example observed by me measures 4 inches in height and in breadth. The examples recorded from the lower horizons are small; the largest of them, from the *Bucklandi*-beds at Redcar, is 1½ inch in height and breadth.

Geological position.—Zones of *Am. Bucklandi*, Redcar, (7 exs.); *A. Jamesoni*, Coatham (1 ex.), Easby (1 ex.); *A. capricornus*, Huntcliff, Staithes; *A. margaritatus*, Huntcliff, Staithes, Danbydale, Easingwold; *A. spinatus*, Eston, Upleatham, Hob Hill, Skelton Park, Belman Mines, &c., Staithes, Hawsker.

This species, which is best known as *P. liasinus*, has its head-quarters in the main seam of ironstone, being there abundant, and of great size.

Pecten calvus, *Goldfuss.*

1834. 'Petref. Germ.' t. xcix. f. 1, p. 74.
Syn. 1834. *P. subulatus.* Münster. Goldfuss. p. 93, t. xcviii. f. 12.

Geological position.—Zones of *Am. angulatus*, Redcar, Slakes Pit, Coatham; *A. Bucklandi*, Redcar, Robin Hood's Bay; *A. oxynotus*, Robin Hood's Bay, Market Weighton; *A. armatus*, Robin Hood's Bay; *A. capricornus*, Huntcliff; *A. margaritatus*, Staithes, Kirby Underdale.

Pecten textilis, *Münster.*

1834. In Goldfuss, 'Petref. Germ.' t. lxxxix. f. 3, p. 43.

Geological position.—Zone of *Am. angulatus*, Cliff.

Pecten punctatissimus, *Quenstedt.*

1858. 'Jura,' t. ix. f. 14, p. 79.

Geological position.—Zones of *Am. angulatus*, Cliff, Millington, Redcar; *A. Bucklandi*, Redcar.

Pecten lohbergensis, *Emerson.*

1870. 'Zeitschr. d. Deutsch. Geol. Ges.' vol. xxii. t. ix. f. 4, p. 318.

Geological position.—Zone of *Am. Bucklandi*, Robin Hood's Bay (3 exs.).

Pecten substriatus, *Römer.*

1836. 'Verst. d. Oolithen Gebirges,' p. 71.
Syn. 1855. *P. reticularis and P. punctatus.* Simpson. 'Foss. Y. L.' pp. 108 and 109.
1858. *P. strionatis.* Quenstedt. 'Jura,' t. xviii. f. 21, p. 117; and t. xxiii. f. 2, p. 183.

Geological position.—Zones of *Am. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Easby; *A. capricornus*, Staithes, Huntcliff, Hummersea; *A. margaritatus*, Peak, Staithes, Huntcliff; *A. spinatus*, Hob Hill and Eston Mines; *A. annulatus*, Skelton Park Pit.

This very fine species is not uncommon in the oyster-bands of the *capricornus*-beds, and in the *margaritatus*-sandstones, specimens from which are large, and in a good state of preservation.

Pecten Pollux, *D'Orbigny.*

1850. 'Prodrome I.' p. 220.
1864. Dumortier. 'Dép. Jurass.' pt. i. p. 65. t. x. fs. 11, 12, and t. xi. fs. 1-4.

Geological position.—Zone of *Am. planorbis* in the oyster-bands at Cliff.

Pecten textorius, *Schlotheim.*

1820. *Pectinites.* 'Petrefactenkunde,' p. 229.
1834. Goldfuss. 'Petref. Germ.' t. lxxxix. f. 9 *a*, *b* (non *c*, *d*), p. 45.

Geological position.—Zones of *A. angulatus*, Slakes Pit, Coatham; *Am. Bucklandi*, Redcar (not uncommon in the shell-bands in the middle portion of the zone), Robin Hood's Bay.

Pecten Thiollieri, *Martin.*

1860. 'Pal. de la Côte-d'Or,' t. vi. fs. 21–23, p. 89.

Geological position.—Zone of *Am. Bucklandi*, Redcar, Marske Bay (middle and upper regions, not uncommon).

Pecten æqualis, *Quenstedt.*

1858. 'Jura,' p. 78, t. ix. f. 13.
Syn. 1855. ?*Multicostatus.* Simpson. 'Foss. Y. L.' p. 109.

Geological position.—Zones of *Am. planorbis*, Cliff; *Am. oxynotus*, Market Weighton, High Stone, Redcar, ?Robin Hood's Bay.

Pecten equivalvis, *Sowerby.*

1816. 'Min. Con.' t. cxxxvi. f. 1.
1828. Young and Bird. 'Geol. Survey,' p. 234.
Syn. 1828. *Sublævis.* Young and Bird. 'Geol. Survey,' p. 234, t. ix. fs. 9, 10.
?1829. *Sublævis.* Phillips. 'Geol. York.' t. xiv. f. 5.
1855. *Sublævis.* Simpson. 'Foss. Y. L.' p. 108.
1856. *Sublævis.* Oppel. 'Die Juraformation,' p. 181.
1828. *Major.* Young and Bird. 'Geol. Survey,' p. 235.
1855. *Major.* Simpson. 'Foss. Y. L.' p. 107.
1875. *Major.* Phillips. 'Geol. York.' p. 246.
1855. *Aheneus, rudis.* Simpson. 'Foss. Y. L.' pp. 108, 109.
1855. *Lima? Runsviciensis.* Simpson. 'Foss. Y. L.' p. 109.

The multiplicity of names applied to this species by Yorkshire geologists requires some explanation. The specific name is, nevertheless, a misnomer, as the shell is decidedly inequivalve, which was pointed out by Young and Bird. Specimens of about two inches diameter present the following characters:—

Right valve moderately convex; ribs about 20, rounded, with flat interspaces crossed by acute concentric costulæ; ears of moderate size, rectangular, and perpendicularly striated, the anterior one the larger; hinge with a distinct oblong tooth on each side of the ligamental pit.

Left valve flat, or nearly so; ribs about 20, broad and flat; interspaces flat, and narrower than the ribs; whole surface faintly striated concentrically; ears unequal, the anterior one small and rectangular, perpendicularly striated; posterior large, half-sagittate, radially and concentrically costated.

P. equivalvis attains to a large size in the *Spinatus*-beds; the largest which I have measured has a length and breadth of

6½ inches; Young and Bird have named it *P. major*: the convex valve has 24 ribs, slightly narrower than the interspaces.

P. sublævis, Young and Bird, is not distinguishable, by their description, from *P. equivalvis*. In their fig. 10, the winged ear is evidently broken, and I incline to the opinion that *P. sublævis* of Phillips is a mere variety of the same species, with more acute ribs than ordinarily, and similar to *P. acuticostatus*, Zieten; it may, however, be *P. priscus*, Schloth. *P. aheneus*, Simpson, is an excorticated specimen of this species or *P. priscus*, and *P. rudis* is nothing more than a largish individual of *P. equivalvis*. *Lima? Runsviciensis*, similar specimens to which we have obtained from a shale-bed in the *Spinatus* series at Kettleness, whence the original comes, is, without doubt, a distorted and partially eroded example of *P. equivalvis*.

Geological position.—Zones of *Am. Jamesoni*, Huntcliff, Rockcliff, Coatham, Bilsdale, Wood End, Ayton, Robin Hood's Bay, Langbargh; *Am. capricornus*, Robin Hood's Bay, Hummersea, Huntcliff; *Am. margaritatus*, Staithes, Huntcliff, Hummersea, Danbydale; *Am. spinatus*, most abundant and large, N.W. Cleveland, Kettleness, Hawsker, Grosmont, Glaizedale, &c.; *Am. annulatus*, Hob Hill, Staithes, Skelton Park.

Pecten priscus, *Schlotheim.*

1820. 'Petrefactenkunde,' p. 222.
1834. Goldfuss. 'Petref. Germ.' t. iv. f. 10, p. 78.
1829. ? *P. sublævis*. Phillips. 'Geol. York.' t. xiv. f. 5.
Syn. 1855. *P. interstinctus, dichotomus*. Simpson. 'Foss. Y. L.' pp. 108, 109.

This species resembles *P. equivalvis*, but the valves are not so dissimilar; the ribs are more numerous and acute, with angular interspaces.

Geological position.—Zones of *A. oxynotus*, Market Weighton (1 ex.); *A. Jamesoni*, Robin Hood's Bay, Warter, Huntcliff, Coatham, Easby, Upsall Sinking; *A. margaritatus* v. *A. spinatus* (*P. interstinctus*, Simpson).

Pecten pumilus, *Lamarck.*

1819. 'Hist. Nat. d. Animaux s. vert.' vol. vi. p. 183.
Syn. 1833. *Personatus*. Zieten. 'Verst. Würtemb.' t. lii. f. 2.
1834. *Personatus*. Goldfuss. 'Petref. Germ.' t. xcix. f. 5.

Geological position.—Zones of *Am. serpentinus*, Skelton Park Pit (1 ex.); *Am. communis*, Whitby and Skelton Park Pit (3 exs.); *Am. Jurensis*, Peak (1 ex.).

Pecten verticillus, *Stoliczka.*

1860. 'Jahrb. Geol. Reich.' p. 197, t. vi. figs. 3, 4.

A doubtfully correct identification.

Geological position.—Zone of *Am. spinatus*, Hotham (1 ex.).

Pecten disciformis, *Schubler.*

1830. Zieten. 'Verst. Würt.' t. liii. f. 2, p. 69.

Geological position.—Zone of *Am. Jurensis*, Peak.

Hinnites papyraceus, *Zieten.*

1836. (*Pecten*). 'Verst. Würt.' p. 70, t. liii. f. 5.

Geological position.—Zone of *Am. communis*, Lofthouse Alum Works (1 ex.).

Hinnites tumidus, *Zieten.*

1833. (*Pecten.*) 'Verst. Würt.' t. lii. f. 1, p. 68.
Syn. 1834. *Pecten velatus.* Goldfuss. 'Petref. Germ.' t. xc. f. 2. p. 45.

Geological position. — Zone of *Am. spinatus*, Eston Mines (1 ex.).

Lima Terquemi, *Tate.*

1867. 'Geol. and Nat. Hist. Repertory,' p. 395.
Syn. 1855. *Tuberculata.* Terquem. 'Pal. de Hettange,' t. xxiii. f. 3 (non Brocchi).

The pre-occupation of the specific name given to this shell by Terquem justifies the adoption of that of *Terquemi* in its stead.

Geological position. — Zone of *Am. angulatus*, Redcar and Millington (rare and fragmentary).

Lima succincta, *Schlotheim.*

1813. (*Chama.*) 'Min. Tasch. v. Knorr,' 3rd sup. t. v. f. 4.
Syn. 1818. *Lima antiquata.* Sowerby. 'Min. Con.' t. ccxiv. f. 2.
1834. *Lima Hermanni.* Goldfuss. 'Petref. Germ.' t. c. f. 5, p. 80.

Geological position.—Zones of *Am. angulatus*, Cliff; *Am. Bucklandi*, Redcar and Marske Bay.

The Redcar specimens agree with *L. nodulosa*, Terq., in possessing numerous fine scaly ribs, a character which seems to belong to all young examples of *L. succincta*, and by which it is distinguishable from *L. Hermanni*, Zieten.

Lima Hermanni, *Voltz.*

1833. Zieten. 'Verst. Würt.' t. li. f. 2.
1835, 75. *Hermanni.* Phillips. 'Geol. York' t. xiv. f. 18.
1828. *Plagiostoma rusticum.* Young and Bird. 'Geol. Survey,' p. 225.
Syn. 1829. Phillips, *loc. cit.* t. xiv. f. 18.
1855. *Lima irregularis.* Simpson. 'Foss. Y. L.' p. 109.
Plagiostoma multicostatum, id. p. 110.

This species has the general form of *L. succincta*, but differs in the details of the ornamentation. The young shells of *L. suc-*

cincta are strongly ribbed, with smaller ones intervening; whilst those of *L. Hermanni* are smooth, with deeply-engraved lines, eventually giving rise to flat broad ribs. Phillips's figure represents this stage of growth of the species.

Geological position.—Zones of *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Normanby Drift, Osborne Rush Pit, Upsall, High Stone, Redcar; *Am. capricornus*, Huntcliff; *Am. margaritatus*, Hawsker, Staithes, Rockcliff, Hummersea, Huntcliff, Danbydale, and bottom seam, Glaizedale, Grosmont, Guisbro'; *Am. spinatus*, Cleveland main seam and subordinate beds, Eston, Upleatham, Hob Hill, Hutton, Belman, Slapewath, and Skelton Park Mines, Staithes.

L. Hermanni is not rare in the lower part of the Middle Lias, but is one of the most common in the *margaritatus* sandstones, specimens from which generally equal 3½ inches in the length of the longer axis. It is abundant in the bottom seam of ironstone, and is not uncommon in the shales above, but is sparsely distributed in the main seam; one specimen in Mr. G. Lee's Collection measures 6 by 5 inches.

Lima punctata, *Sowerby*.

1815. (*Plagiostoma.*) 'Min. Con.' t. cxiii. f. 152, p. 25.

Geological position.—Zone of *Am. angulatus*, Cliff, Eston Gypsum Pit.

Lima gigantea, *Sowerby*.

1814. (*Plagiostoma.*) 'Min. Con.' t. clxxvii.
1829. (*Plagiostoma.*) Phillips. 'Geol. York.'
1855. Simpson. 'Foss. Y. L.' p. 110.
Syn. 1855. *Plagiostoma excavatum.* Simpson, *loc. cit.* p. 110.

Geological position.—Zones of *Am. planorbis*, Cliff; *Am. angulatus*, Cliff, Redcar, Staithes Pit, Coatham; "Lower shale N. Cliff and Pocklington" (Phillips); *A. Bucklandi*, Robin Hood's Bay, Redcar, and Marske Bay, Sigston, Ellerbeck; *A. oxynotus*, a juvenile example, in the region of *A. raricostatus*, Robin Hood's Bay.

Lima Eucharis, *D'Orbigny*.

1850. 'Prodrome I.' p. 237.

I include under this name a shell most commonly met with in the main seam of ironstone, varying in shape from oval to nearly circular, smooth, or faintly striated. It resembles *L. gigantea*, and though no very good character is presented, yet they are distinguishable. The largest known specimen measures 2½ inches in the length of the longer axis, and 2 inches in the transverse. *L. gigantea*, Phillips, from the Marlstone at Staithes, doubtless belongs here.

Geological position.—Zones of *Am. Jamesoni*, Huntcliff, Coatham, and Easby; *Am. margaritatus*, Staithes, Huntcliff; *A. spinatus*, Staithes, Skinningrove, Hob Hill, Upleatham, Eston, and Belman Mines.

Lima toarcensis, *Deslongchamps.*

1856. 'Bull. Soc. Linn. de Normandie,' p. 79.

A shell related by its size and aspect to *L. gigantea*; but our specimens are not in a sufficiently good state of preservation to permit a critical comparison.

Geological position.—Zone of *Am. Jurensis*, Peak.

Lima pectinoides, *Sowerby.*

1816. (*Plagiostoma.*) 'Min. Con.' p. 28, t. cxiv. f. 4.

"Depressed, a little oblique, obovate, rather angular at the beak, beak pointed; surface with 20 or more carinated ribs, transversely striated."—Sow. The interstitial spaces are usually occupied by a simple thread, which is occasionally compounded of about 3; other examples show no sign of an intermediate rib.

Geological position.—Zones of *Am. angulatus*, Cliff, Redcar, Coatham (Slake's Pit), Eston (Gypsum Pit); *Am. Bucklandi*, Redcar and Marske Bay; *Am. oxynotus*, Robin Hood's Bay (lower and middle regions).

This shell is common in the *angulatus*- and *Bucklandi*-beds.

Lima hettangiensis, *Terquem.*

1855. 'Pal. de Hettange,' t. xxviii. f. 1, p. 320.

This species has a general resemblance to *L. pectinoides*, but is more closely related to *L. duplicata*, Sow., from the Coralline Oolite, from which it differs in the less obliquity of the shell. It is more inflated and oblong than *L. pectinoides*, and the surface of the acute ribs is minutely granulated by the crossing of vertical and transverse striæ.

Geological position.—Zones of *Am. angulatus*, Millington, Eston Gypsum Pit, Topcliffe; *A. Bucklandi*, Robin Hood's Bay.

Limea acuticosta, *Münster.*

1836. Goldfuss. 'Petref. Germ.' t. cvii. f. 8, p. 103.
Syn. 1829, 35, 75. *Plagiostoma pectenoideum.* Phillips. 'Geol. York.' t. xii. f. 13.
1855. *Plagiostoma pectenoideum.* Simpson. 'Foss. Y. L.' p. 110.
1855. *Plagiostoma novemcostatum*, id. p. 110.

This species has some resemblance to *L. pectinoides*, but is less oblique; the ribs are about 15 in number, subacute, crossed by waving threads. The ribs are acute in the umbonal region, the

lateral areas are costated. *P. pectenoideum*, Phillips (*Lima galathea*, D'Orb.) is a cast, and though quoted from the Upper Lias, has probably come from the *Armatus*- or *Jamesoni*-beds, whence all the species quoted by that author from calcareous nodules, which I have examined, have been obtained. Simpson's examples are stated to belong to the Middle Lias, and these I have no hesitation in referring to *L. acuticosta*. His *P. novemcostatum* is a cast from the *Armatus*-zone, and presents all the characters of the nucleus of *L. acuticosta*. Examples from the several horizons given below have been examined, and are proved to have the hinge characters of the genus, whilst their external ornament and shape supply the specific ones.

Geological position.—Zones of *Am. Jamesoni*, Robin Hood's Bay, Langbargh, Kirby Underdale, Husthwaite, Peak, Huntcliff, Coatham, Normanby Drift, Wood End; *A. capricornus*, Huntcliff, Staithes; *A. margaritatus*, Huntcliff, Staithes, Hawsker, Easingwold; *A. spinatus*, Hawsker, Hob Hill, Upleatham, Eston Mines, &c., in N. Cleveland; *A. annulatus*, Grosmont, Hutton, Upleatham district, and S. of Whitby.

A common fossil throughout the Middle Lias.

Limea Juliana, *Dumortier*.

1869. 'Dépôts Jurassiques,' vol. iii. t. xxxiv. fs. 7, 8, p. 289.

I refer to this species a *Limea*, resembling *L. pectinoides*. It has about 20 subacute ribs, interspaces usually occupied by a thread; transversely striated; lateral areas without costæ, or only faintly striated; beaks acute, arched.

Large casts, presumably of this species, measure 1½ inch in the length of the longer axis.

Geological position.—Zones of *A. spinatus*, Main Seam, Hob Hill, Upleatham, and Hutton Mines (12 exs.); *A. Jamesoni*, Robin Hood's Bay (3 exs.).

Limea Blakeana, *Tate*.

Pl. XIV., fig. 5.

Syn. 1872. *Cardium profundum*. Blake. 'Quart. Jour. Geol. Soc.' vol. xxviii. p. 143.

Shell ovate, convex, nearly equilateral, hinge-line straight, short, ornamented with about 20 subacute ribs, transversely striated; interspaces narrow, with or without a rib; lateral areas costated.

Most of the examples show a light-coloured band bordering the margin. Its more numerous ribs separate it from *L. acuticosta*. If my interpretation of the internal characters of *Cardium profundum*, so named by my coadjutor, be correct, then it may belong to this species, as it presents externally a like ornament; the hinge is, however, incomplete, and the specimen minute.

Geological position.—Zones of *Am. angulatus*, Redcar (2 exs.), Cliff (1 ex.); *A. Bucklandi*, Redcar (7 exs.).

Plicatula liasina, *Terquem.*

1855. *Spondylus liasinus.* Terquem. 'Pal. de Hettange,' t. xxiii. f. 7, p. 327.
1865. *Plicatula liasina.* Terquem and Piette. 'Lias inf.' &c. t. xiii. fs. 11–13, p. 107.

Left valve ovate-oblong, attached by a more or less broad surface, with the front elevated; ornamented by numerous slender, rounded, and serrated dichotomous ribs, with linear interspaces, transversely wrinkled; interior surface with dichotomous ribs widely separated.

Right valve flat or concave, smooth in the umbonal region, outwardly lamellose, and radially striated. Interior ornamented with distant dichotomous ribs, crowded around the outer margin; hinge with two small teeth, parallel with the hinge line.

The similarity of internal ornament presented by this species and the Rhætic *Ostrea intusstriata* is no proof of specific identity, and the figures and descriptions of typical examples of the latter do not serve for critical comparison.

Geological position.—Zones of *Am. angulatus* and *A. Bucklandi* (lower part), Redcar. Exceedingly abundant in the lower zone. *Am. Angulatus*, Millington.

Plicatula spinosa, *Sowerby.*

1819. Sowerby. 'Min. Con.' t. ccxlv. fs. 1–4.
1828. Young and Bird. 'Geol. Survey,' p. 229, t. ix. p. 6.
1829. Phillips. 'Geol. York. Coast,' t. xiv. f. 16.
1855. Simpson. 'Foss. Y. L.' p. 111.

Geological position.—Zones of *Am. Jamesoni* (universally abundant), Peak, Robin Hood's Bay, Rockcliff, Huntcliff, and Coatham on the coast, Wood End, and Easby, near Ayton, Osborne Rush Pit, Upsall; *A. capricornus*, Staithes, Huntcliff (rare); *A. spinatus*, main seam of ironstone, Eston, &c. (possibly this species).

Plicatula calva, *Deslongchamps.*

1858. *Harpax calvus.* 'Plicatules Foss.' t. xii. fs. 10–13, p. 57.
Syn. 1855. *Placuna ferruginea.* Simpson. 'Foss. Y. L.' p. 110.

The type of *P. ferruginea* (Simpson) shows only the interior aspect of a very large *Plicatula*, which, though somewhat larger than the usual sized specimens of *P. calva*, yet is probably that species.

Geological position.—Zones of *Am. spinatus*, in the shale below the main seam of ironstone, where it is abundant. Eston, Upleatham, Hob Hill, and Belman Mines, Staithes, Hawsker. A

valvis (Var. β Sow.), *A. Roseburiensis* (Y. and B.), *A. novemcostæ* (Brown), and *A. Sinemuriensis* (D'Orb.), which are all synonymic names.

The transverse markings on the left valve are usually fine, and confined to the umbonal region, but specimens are not wanting in which the whole surface is cancellated; these agree with *A. acuticostæ*, Terq. and Piette, and have been obtained from the *Bucklandi*- and *spinatus*-beds. Associated with them in the latter set of strata are others with a transversely-wrinkled or scaly exterior, the ribs numbering 14 in some, and 30 in others; the latter may have claims to specific distinction. With regard to the number of primary ribs, they rarely fall below 14, though as few as 10 have been observed. In the Upper Lias specimens they vary from 15 to 24; those with the lower number agree with Young and Bird's *A. crescens*.

Geological position.—Zones of *Ammonites Bucklandi*, Redcar; *A. oxynotus*, Robin Hood's Bay, High Stone, Redcar; *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, and Easby; *A. capricornus*, Huntcliff, Staithes; *A. margaritatus*, Huntcliff, Rockcliff, Staithes, Roseberry, Stokesley Hills, Danbydale, Raisdale, &c., Thormanby; *A. spinatus*, Hutton, Eston, Upleatham: *A. annulatus*, Skelton Park Pit; *Am. communis*, Whitby, Skelton Park Pit; *Am. jurensis*, Peak.

The species is abundant in the middle and upper parts of the *Bucklandi*-zone, in the oyster and shell bands in the *capricornus*- and *margaritatus*-beds; and is moderately common in the *jurensis*-zone. The largest examples have been collected in the *Jamesoni*-beds at Easby, in the *capricornus* and *margaritatus*-beds on the coast, and in the *jurensis*-series at Peak; they measure 2½ inches in diameter.

Monotis papyria, *Quenstedt.*

1858. 'Jura,' t. xiii. fs. 31 and 32, p. 109.

Geological position.—Zones of *A. Bucklandi*, Redcar; *A. spinatus*, Skelton Park Pit, Hob Hill, in shale below ironstone; *A. annulatus*, Staithes.

Monotis substriatus, *Münster.*

1831. Brauns's 'Jahrbuch,' p. 406.
1836. Goldfuss, 'Petref. Germ.' t. cxx. f. 7, p. 138.
Syn. 1855. *Avicula minima*, *A. nitescens*, *A. tumidulus*, *A. crescens*. Simpson. 'Foss. Y. L.' p. 112.
1828. *A. crescens*, *pars*. Young and Bird, p. 237.
1829. *Avicula* (cf.) *echinata*. Phillips. 'Geol. York.'

A. crescens, Young and Bird, as figured by them, belongs to *A. inæquivalvis*, but they included therewith shells having 50 or 60 slender ribs; these Simpson has called *A. crescens*, but they are large examples of *Monotis substriatus* with numerous coarse ribs.

Geological position.—Zones of *Am. spinatus*, Upleatham (1 ex.); *Am. serpentinus*, Saltwick (Simpson), Skelton Park Pit, &c. (common); *Am. communis*, Lofthouse and Boulby, Whitby, &c. (common); *Am. jurensis*, Peak (abundant) and Inferior Oolite, Blea Wyke.

Cassianella contorta, *Portlock.*

1843. *Avicula contorta.* 'Geol. Londonderry,' t. xxv. f. 16, p. 126.

This well-known Rhætic fossil is quoted as a *Cassianella* on the authority of Brauns ('Der. Unt. Jura,' p. 37, 1871).

Geological position.—Rhætic Beds, Eston Gypsum Pit (Mr. G. Lee), near Northallerton, a well-sinking Hill-top near Thornton-le-Beans, and Howsham.

Posidonomya Bronni, *Voltz.*

1833. Zieten. 'Verst. Würt.' t. lvii. f. 4.
1834. Goldfuss. 'Petref. Germ.' t. cxiii. f. 7.

First recorded as a Yorkshire shell by Oppel in 1856.

Geological position.—Zone of *Ammonites serpentinus*, Saltwick, Whitby, East Arncliffe, Glaizedale, Alum Works, Osmotherley.

Gervillia ærosa, *Simpson.*

Pl. XIV. fig. 6.

1855. 'Fossils of the Yorkshire Lias,' p. 111.

"Very oblique, wing large, beaks obtuse, many undulations or marks of growth." Length of oblique axis 1¾ inch, height 1¼ inch, length of hinge 1 inch, are the dimensions of the largest specimen.

Intermediate in form between *G. lævis*, Buckman, and *G. betacalcis*, Quenstedt, but having greater resemblance to the latter.

Geological position.—Zones of *Am. Jamesoni*, Robin Hood's Bay; *Am. capricornus* (common in the oyster bands), Staithes, Hummersea; *A. margaritatus*, in the sandstones not rare, Huntcliff.

Gervillia Hagenovii, *Dunker.*

1847. 'Lias von Halberstadt, Palæontographica I.' t. vi. fs. 9–11, p. 37.

Geological position.—Zones of *Am. Bucklandi* (upper beds), Redcar and Marske Bay; *A. oxynotus*, High Stones Redcar.

Perna infraliassica, *Quenstedt.*

1858. 'Der Jura,' p. 48, t. iv. f. 19.

Geological position.—Zones of *Am. angulatus*, Cliff, Redcar; *Am. Bucklandi*, Redcar.

Perna lugdunensis, *Dumortier.*

1868. 'Dép. Jur.' vol. iii. p. 297, t. xxxvi. fs. 1, 2.
Syn. 1867. ? *Perna antiqua.* Moore. 'Mid. and Up. Lias,' p. 102.
1822. *Perna quadrata* (*Sow.*)? Young and Bird. 'Geol. Sur.' p. 221.

A *Perna* obtained by Mr. C. Rippon from the shale at the base of the ironstone seam at Hob Hill may safely be referred to Dumortier's species; this rare example is however only 2½ inches long and 1½ in breadth. From the curt description and in the absence of a figure of *P. antiqua* it would be hazardous to unite therewith *P. lugdunensis.* Young and Bird notice: "A large shell, apparently *Perna quadrata*, Sow., occurs in the ironstone of the Kettleness beds," which is probably the present species. A good specimen of this species is also in the Bean Collection in the British Museum.

Inoceramus Simpsoni, *Spec. nov.*

Pl. XVI., fig. 10.

Syn. 1855. *Gervillia rugata.* Simpson, *loc. cit.* p. 111.

Subquadrate, depressed, thin, umbo acute, approximately terminal; cardinal line straight or moderately oblique; anterior margin subsinuous, posterior slightly arched or nearly straight; surface ornamented by concentric imbricating lamellæ and folds, and by radial plications and striæ.

The shell varies in the amount of obliquity of the hinge line and in the strength of the radial plicæ; in some specimens the latter are thick, and by the interruption of the concentric folds, a nodulose ornamentation is produced.

On account of its thin test and imbricating lamellæ, characters in common with *Inoceramus dubius*, I place this species in the same genus, despite its Perna-like form.

The only liassic Aviculid which approaches the present species in style of ornament is *Avicula imbricata*, Moore, but with which it does not agree in shape, whether the two be congeneric or not.

Dimensions.—Length of hinge line ·55 inch, length of oblique axis through the umbo 1 inch.

Geological position.—Zone of *Am. serpentinus*, Whitby (about 50 examples on a single slab, Whitby Museum, also in Scarborough Museum).

This species is dedicated to Mr. Martin Simpson, to whose valuable contributions to the liassic palæontology of the Yorkshire coast frequent reference has been already made.

Inoceramus pinnæformis, *Dunker*.

1848. *Gervillia pinnæformis*. 'Palæontographica I.' t. xxv. fs. 10, 11, p. 179.
Syn. 1858. *Mytilus psilonoti*. Quenstedt. 'Jura,' t. iv. f. 14, p. 48.

Geological position.—Zone of *Am. Bucklandi*, Redcar, Robin Hood's Bay.

Inoceramus ventricosus, *Sowerby*.

1823. *Crenatula ventricosa*. Sowerby. 'Min. Con.' t. ccccxliii.
1828. Young and Bird, *loc. cit.* p. 228.
1855. Simpson. 'Foss. Y. L.' p. 111.

First recorded as a Yorkshire fossil by Young and Bird as occurring in the hard bands on the shore, and subsequently confirmed by Phillips.

Geological position.—Zones of *A. armatus*, Robin Hood's Bay; *A. capricornus*, Huntcliff, Staithes, and Hawsker.

Inoceramus substriatus, *Münster*.

1836. Goldfuss. 'Petref. Germ. II.' t. cix. f. 2.

Geological position.—Zones of *A. capricornus*, Huntcliff; *Am. annulatus*, Hutton and Grosmont (doubtful identifications); *Am. margaritatus*, Staithes (very rare); *A. spinatus*, Hawsker, Kettleness, Eston, Hob Hill, and Belman Mines (several examples).

Inoceramus dubius, *Sowerby*.

1823. Sowerby. 'Min. Con.' t. dlxxxiv. f. 3.
1829. Phillips. 'Geol. York.' t. xii. f. 14.
1855. Simpson. 'Foss. Y. L.' p. 111.
Syn. 1855. *Ostrea Saltviciensis*. Simpson, *loc. cit.* p. 106.

The figured specimen of this species Sowerby obtained from the neighbourhood of Whitby; it is in the condition of a thin, shelly film, in which it more commonly occurs, constituting extensive layers between the partings of the Jet Rock. A cast of the same has been described by Simpson as an *Ostrea*. Specimens retaining their original form may be obtained from the doggers in the same bed; one in this state of preservation has been figured by Phillips as a variety. Young and Bird confounded it with *Mytilus edulis*, but their figure (t. vii. fig. 3) well represents the fossil.

Some authors have endeavoured to prove that *Inoceramus dubius*, Sow., is identical with *Mytilus gryphoides*, Schloth., but of the generic position of Sowerby's shell there cannot be a doubt; I have now before me a specimen, the interior of which presents 8 ligamental sockets, and another, the thick test of which is clearly prismatic.

Geological position.—Zone of *Ammonites serpentinus*. Passim.

Inoceramus cinctus, *Münster.*

1836. Goldfuss. 'Petref. Germ.' t. cxv. f. 5, p. 110.
1856. Oppel. 'Die Juraform.' p. 261.

Recorded by Oppel from the Alum Shale of Whitby. I have examples from the upper part of the same horizon at Lofthouse Alum Works.

Pinna Hartmanni, *Zieten.*

1832. 'Verst. Würt.' t. lv. f. 5.
Syn. 1872. *Pinna semistriata.* Blake. 'Quart. Jour. Geol. Soc.' vol. xxviii. p. 143.

A nearly complete specimen from the Redcar Scars has a length of 7¼ inches, and a width of 4½.

Geological position.—Zones of *Am. angulatus*, Cliff, Slake's Pit, Coatham; *A. Bucklandi*, Redcar and Marske Bay; *A. oxynotus*, High Stones Redcar.

Pinna folium, *Young and Bird.*

1822. 'Geol. Surv. York. Coast,' t. x. f. 6.
1829. Phillips. 'Geol. York.' t. xiv. f. 17.
1855. Simpson. 'Foss. Y. L.' p. 113.
Syn. 1855. *Perna quadrata.* Simpson, *loc cit.* p. 113.

Geological position.—Topmost beds of *A. oxynotus*, Robin Hood's Bay; sub-zone of *Am. armatus*, Robin Hood's Bay and Warter. Most abundant in the *Jamesoni*-Beds, Robin Hood's Bay, Peak, Rockcliff, Huntcliff, Coatham, Easby, Wood End, Bilsdale, &c.

Pinna spathulata, *Spec. nov.*

Pl. XIV., fig. 2.

Shell pyramidal, compressed; valves ovate, lanceolate, attenuated towards the apex, height twice the width, regularly convex on the sides with depressed margins, ornamented by a few radial lines and strong ridges of growth. Height 8 inches, width 4 inches.

Geological position.—Casts of this species are not rare in the main seam of ironstone; a few imperfect specimens with the test are known. Eston, Upleatham, Hob Hill, Hutton and Belman Mines, Hawsker (Whitby Mus.). Zone of *A. annulatus*, Boosbeck, Hob Hill, Skelton Park. (Impression only, probably of this species.)

Mytilus aviothensis, *Buvignier.*

1852. 'Geol. de la Meuse,' &c. t. xvi. fs. 35–37, p. 21.

The cast shows many close-set radial lines.

Geological position.—Zone of *Am. spinatus*, Belman Mines,

Guisbro' (Mr. T. Allison), Challoner Mines (Mr. G. Lee), Eston Mines (12 exs.).

Modiola minima, *Sowerby.*

1818. 'Min. Con.' t. ccx. fs. 5-7.

Geological position.—*Rhætic* Beds, Eston Gypsum Pit, and zone of *Am. planorbis*, Hotham, Leavening, Cliff, near Northallerton, Eston Gypsum Pit.

Modiola lævis, *Sowerby.*

1816. 'Min. Con.' t. viii. f. 4.

I regard this as a distinct from *M. minima*, with which it is associated in the White Lias at Westbury on Severn; it is an elongated shell, slightly curved, and of a sub-triangular shape, with small umbos, whilst *M. minima* is reniform, with inflated umbos, and a broad anterior area. It may be the young of *M. Hillanoides*, but surely not of *M. Hillana*, as suggested by Brauns. It makes an approach to *M. nitidula*, Dunk., but is not so slender.

Geological position.—Zones of *Am. planorbis*, Cliff; *A. angulatus*, Cliff, Slake's Pit, and well sinking, Coatham, Redcar; *A. Bucklandi*, Redcar, Robin Hood's Bay; *A. oxynotus?* Robin Hood's Bay (Whitby Mus.).

Modiola Hillana, *Sowerby.*

1818. 'Min. Con.' t. ccxii. f. 2.

Geological position.—Zone of *Am. angulatus*, Millington, one example, which agrees with *M. glabrata*, Dunker, and is doubtless a young shell of *M. Hillana*.

Modiola Hillanoides, *Chapuis and Dewalque.*

1853. *Mytilus Hillanoides.* 'Terr. Sec. du Luxem.' t. xxv. f. 3, p. 185.
1858. *Modiola psilonoti.* Queenstedt's 'Jura,' t. iv. fig. 13.

I apply Chapuis and Dewalque's name to a *Modiola*, occurring very generally in the lower beds of the Lower Lias; in England it is more frequently named *M. Hillana*, whilst it is distinguishable from *M. scalprum* by its shorter and straighter form.

Geological position.—Zones of *Am. angulatus*, Eston Gypsum Pit, Redcar; *Am. Bucklandi*, Redcar.

Modiola scalprum, *Sowerby.*

1821. Sowerby. 'Min. Con.' t. ccxlviii. f. 2.
1829. Phillips. 'Geol. of York.' t. xiv. f. 2.
Syn. 1828. *Modiola siliqua.* Young and Bird, p. 222, t. vii. f. 1.
1855. *Modiola siliqua* and *curvata.* Simpson. 'Foss. Y. L.' p. 117.

Sowerby first gave the name of *M. cuneata* to this species, but

afterwards changed it to that which it now bears. Young and Bird considered that *M. siliqua* was a more appropirate name, from its striking resemblance to a large pod. *M. siliqua*, Simpson, is a small, slender, curved shell; and his *M. curvata* is similar, but of larger growth, both of which come from the *oxynotus*-beds in Robin Hood's Bay.

Geological position.—Zones of *Am. oxynotus*, Robin Hood's Bay; *A. Jamesoni*, Robin Hood's Bay, Coatham, High Stones Redcar; *A. capricornus*, Staithes, Hummersea, Huntcliff, Robin Hood's Bay; *A. margaritatus*, Huntcliff; *A. spinatus*, Hob Hill, Eston, Belman and Hutton Mines (rare); *A. annulatus*, Whitby (doubtful).

Modiola numismalis, *Oppel.*

1853. 'Mittlere Lias Schwabens,' &c., t. iv. f. 17, p. 83.
1869. Dumortier. 'Dépôts Jurassiques,' vol. iii. p. 126, t. xix. fs. 8-9.
Syn. 1855. *Modiolus pygmæus.* Simpson. 'Foss. Y. L.' p. 119.

This is an elongated shell, compressed, arched posteriorly, with a nearly straight margin; surface nearly smooth, by which it is separable from *M. scalprum.*

Geological position.—Zones of *Am. Jamesoni*, Kirby Underdale, Langbargh, Warter, Huntcliff and Coatham, Robin Hood's Bay; *A. capricornus*, Hawsker, Huntcliff. Specimens from the foregoing localities are casts or crushed; the identifications are doubtful. *A. margaritatus*, Staithes; *A. spinatus*, Grosmont, Upleatham, Eston, Hob Hill and Belman Mines; *A. annulatus*, Skelton Park Pit, near Whitby (Whitby Mus.).

Modiola Thiollierei, *Dumortier.*

1869. *Mytilus.* 'Dép. Jur.' Pt. III. p. 284, t. xxxiv. fs. 5 and 6.

According to Brauns, *M. Thiollierei* is identical with *M. elongata*, Koch and Dunker. It may be so, but the drawing of it does not justify such an opinion. The specific name *M. Kochii*, D'Orb., should be used, as there is a *Modiola elongata* of earlier date.

Geological position.—Zones of *Am. capricornus*, Huntcliff; *A. margaritatus*, Huntcliff; *A. spinatus*, Hutton near Guisbro'. An example from each horizon.

Modiola subcancellata, *Buvignier.*

Pl. XIII., fig. 1.

1852. 'Géol. Meuse,' p. 21, t. xvii. fs. 17-19.
Syn. 1855. *Modiolus pallidus.* Simpson. 'Foss. Y. L.' p. 119 (non Sow.).
1867. *Modiola ornata.* Moore. 'Up. and Mid. Lias,' p. 101, t. vii. f. 7. (non Gold.).
1869. *Mytilus Moorei.* Dumortier. 'Dép. Jur.' iii. t. xxxv. f. 1. p 283.

Geological position.—Zone of *Am. margaritatus* (lower part),

Huntcliff, Hummersea, Rockcliff, Staithes, Grosmont (in the bottom seam of ironstone).

Modiola bifasciata, *Spec. nov.*

Pl. XI., fig. 3.

Shell small, intermediate in shape, between *M. minima*, Sow., and *M. lævis*, Sow.; surface ornamented with imbricating rugæ of growth and radial plicæ on the posterior area. The radial ornament is obsolete in some specimens, whilst the concentric folds are stronger in the same than in those which possess the posterior plications.

Geological position. — Zone of *Am. Bucklandi*, Redcar (10 examples).

Macrodon hettangiensis, *Terquem.*

1855. (*Cucullæa.*) 'Pal. de Hettange,' t. xxi. f. 3.
Syn. 1861. *Arca Lycetti.* Moore. 'Quart. Jour. Geol. Soc.' vol. xvii. t. xvi. f. 7, p. 501.

Geological position.—Zones of *Am. planorbis*, Cliff, near Northallerton, Eston Gypsum Pit; *Am. angulatus*, Redcar, Eston Pit, Cliff; *Am. Bucklandi*, Redcar and Marske Bay? Robin Hood's Bay.

Macrodon naviculus, *Terquem and Piette.*

1865. *Cucullæa navicula.* 'Lias inf. de l'Est de la France,' t. xi. fs. 16–17, p. 91.

Geological position.—Zone of *Am. angulatus*, Cliff; and *Am. Bucklandi*, Redcar and Marske Bay; *A. oxynotus*, Robin Hood's Bay (1 ex. doubtful).

Macrodon pullus, *Terquem.*

1855. (*Arca.*) 'Pal. de Hettange,' t. xxi. f. 1, p. 307.

Geological position.—Zones of *Am. angulatus* and *A. Bucklandi*, Redcar.

Macrodon Buckmani, *Richardson.*

1845. *Arca Buckmani.* Murchison's 'Geol. Cheltenham,' t. x. f. 5, p. 96.

Geological position.—Zones of *Am. margaritatus*, Thormanby (1 ex.); *Am. spinatus*, Eston and Hob Hill Mines (4 exs.).

All our ironstone specimens are exceedingly small, the largest $\frac{7}{12}$ths of an inch only in length.

Macrodon intermedius, *Simpson.*

1855. *Cucullæa intermedia.* Simpson. 'Foss. Y. L.' p. 114.
Syn. 1843. *Cucullæa cucullata.* Portlock. 'Geol. Londonderry,' p. 120.
1855. *Cucullæa incrassata, expansa, cuspidata.* Simpson. 'Foss. Y. L.' pp. 113, 114.
1870. *Cucullæa Grangeri.* Tate. 'Irish Lias. Foss.' p. 19. t. i. f. 12.
1870. *Arca numismalis.* Tate. 'Quart. Jour. Geol. Soc.' vol. xxvi. t. xxvi. f. 3.

If I read aright Goldfuss's description and figure of *Cuc. Münsteri* (Zieten's figure represents a cast) and correctly interpret the hinge characters of our common Middle Lias Ark-shell, then is it a distinct species, having a closer agreement with *M.* (*Arca*) *liasina*, Röm. According to Brauns the former is a true *Cucullæa*, whilst the latter is a *Macrodon*, as is our shell. Its nearest ally in shape and ornament is *C. cancellata*, Phillips, as pointed out by Simpson. It exhibits some variation in shape and in the position of the umbos. Simpson's description of his *C. intermedia* is applicable to the majority of specimens, but a combination of the characters given for *C. intermedia* and *C. incrassata*, fully describes the species. My *C. Grangeri* is identical with it, and my *Arca numismalis* is the young of the same. *C. expansa* and *C. cuspidata*, Simpson, are casts conjecturally of this shell, and the smooth *Cucullæa*, mentioned by Phillips, may possibly be the same.

M. intermedius is widely distributed in England (Moore names it *C. bilineata*), whilst the *C. Münsteri* with which it is confounded seems to be rare. I know few examples comparable with this. The shell ovate, rhomboidal ventricose, rounded in front, and obliquely truncated or slightly rounded behind; bluntly or sharply keeled from the umbo to the posterior angle; umbones usually post-medial, prominent, high, and incurved, sub-approximate. Surface cancellated by very numerous and fine concentric and radiating striæ. The long posterior teeth are minutely denticulated on the sides, as in other *Macrodons*, which I have examined. Very young shells are oblong and inflated, without a keel, but radially impressed; ornamented by concentric and a few distant prominent radial ribs.

The species varies in the position of the umbones, in the shape of the posterior area and strength of the keel.

Dimensions of largest specimen :—Length $\frac{8}{12}$ths inch, breadth $\frac{11}{12}$ths inch. This the shell that we have called *Cucullæa Münsteri* in Part I.

Geological position.—Zones of *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Easby, Garrowby ; *Am. capricornus*, Huntcliff; *Am. margaritatus* (upper part), Staithes; *Am. spinatus*, a very characteristic shell. Eston, Upleatham, Kettleness, Grosmont, Bransdale, Hawsker; *Am. annulatus*, Hob Hill, Grosmont, Spa Wood, Guisbro', Skelton Park Pit.

Macrodon pulchellus, *Spec. nov.*

Pl. XIII., fig. 2.

Shell trapezoidal; beaks a little in front of the median line, elevated, sub-acute, and approximate; anterior margin rounded, posterior sharply truncated, front slightly arched or nearly straight. A strong, serrated keel proceeds from the umbo to the posterior angle, forming a sub-concave triangular area behind. Whole surface ornamented by numerous radial costulæ and by concentric striæ, the latter producing spinous serrations on the sharp keel.

Dimensions: length $\frac{1}{12}$th inch, breadth $\frac{2}{12}$ths inch.

Geological position.—Zone of *Am. Jamesoni*, Kirby Underdale (2 exs.). Mr. J. Slatter has collected several specimens from the Jamesoni-beds at Aston Magna, Gloucestershire.

This species is obviously distinct from the young of *M. intermedius*, and differs from *M. pullus* in its strong keel, and in the absence of a medial sinus.

Macrodon clevelandicus, *Spec. nov.*

Pl. XI., fig. 6.

Shell ovate-trapezoidal, ventricose, umbones slightly postmedial, large, elevated, approximate, incurved and directed forwards; anterior extremity rounded, posterior bluntly keeled, posterior area very narrow, sub-concave; front margin gently curving; surface ornamented with concentric furrows and lines of growth. The anterior area shows faint indications of radial lines.

Dimensions: length $2\frac{1}{2}$ inches, breadth $3\frac{1}{4}$ inches.

This shell may possibly be an aged example of *M. intermedius*, but, not having found specimens of intermediate growths, I cannot entertain the notion of their identity.

Geological position.—Zone of *Am. spinatus*, Hob Hill, Eston, and Challoner Mines (9 exs.).

Cucullæa Münsteri ? *Zieten.*

1830. 'Verst. Würt.' t. lvi. f. 7, p. 75.
1858. Quenstedt. 'Jura,' t. xviii. f. 34, p. 150, and t. xxiii. f. 8, p. 185.
Syn. 1855. *Cucullæa obtusalis.* Simpson. 'Foss. Y. L.' p. 115.

Ill-preserved specimens of an ark not common in the lower part of the Middle Lias agree with Quenstedt's figures of *C. Münsteri*. This is not the shell we so call in Part I. See *M. intermedius*.

Geological position.—Zones of *Am. oxynotus*, Robin Hood's Bay; *A. Jamesoni*, Robin Hood's Bay, Huntcliff; *A. capricornus*, Huntcliff.

Nucula navis, *Piette.*

1856. 'Bull. Soc. Géol. de France,' p. 206, t. x. f. 3.
1865. Terquem and Piette. 'Lias inf.' ts. x. f. 8–10, p. 90.

Geological position.—Zones of *Am. angulatus* and *A. Bucklandi*, Redcar and neighbourhood (very common); *Am. oxynotus*, Robin Hood's Bay (one large example).

Nucula cordata, *Goldfuss.*

1837. 'Petref. Germ' t. cxxv. f. 6, p. 155.

Geological position.—Zone of *A. Jamesoni*, Huntcliff; sub-zone of *A. armatus*, Robin Hood's Bay, Warter; *A. spinatus*, Bransdale, Glaizedale; *A. annulatus*, Hob Hill, Staithes.

Leda subovalis, *Goldfuss.*

1837. (*Nucula.*) 'Petref. Germ.' t. cxxv. f. 4. p. 155.
Syn. 1829. *Corbis uniformis.* Phillips. 'Geol. York.' t. xii. f. 3.
1855. *Corbis uniformis.* Simpson. 'Foss. Y. L.' p. 121.
1858. *Leda Bronni.* Andler. 'N. Jahrb. f. Min.' p. 642.
1870. *Leda Bronni.* Tate. 'Irish Liassic Foss.' t. i. f. 1.

The type of Phillips's *Corbis uniformis* is not a very satisfactory specimen, but I have little doubt but that it is *Leda subovalis*, subsequently named by Goldfuss. The specimen in the Whitby Museum has the valves in opposition, so that its generic position is not certain; however, a specimen in our possession similar in size and form is referable to *Leda subovalis*. The characters relied on for specific distinction of *L. Bronni* are not constant, so that the name is a mere synonym.

Geological position.—Zones of *Am. Bucklandi*, Redcar and Marske Bay (4 exs.), Robin Hood's Bay (1 ex.); *Am. oxynotus*, Robin Hood's Bay (1 ex.); *Am. Jamesoni*, Huntcliff (1 ex.); and sub-zone of *A. armatus*, Robin Hood's Bay; *Am. spinatus*, Kettleness, Runswick, Staithes, Hob Hill, Eston, and Normanby (not rare).

Leda æquilatera, *Koch and Dunker.*

Pl. XI., fig. 10.

1837. *Tellina æquilatera.* 'Verst. Nordd. Ool.' p. 30, t. ii. f. 9.
Syn. 1855. *Nucula tellinæformis.* Simpson. 'Foss. Y. L.' p. 115.
1875. ? *Rostralis.* Sow. Phillips. 'Geol. York.' p. 249.

This species is allied to *L. subovalis*, but is a more depressed shell, and is acuminate posteriorly.

Geological position.—Zone of *Am. Jurensis* Peak, where a few specimens have been obtained. This species is quoted chiefly from the lower beds of the Inferior Oolite on the continent, but occurs in subordinate beds to those with *A. Jurensis*, in Aveyron. One example was collected from the *Opalinus*-beds at Blea Wyke

Point. Two minute *Ledas* obtained from the base of the Alum Shale, Skelton Park Pit, have some affinity with *L. æquilatera.*

Leda galathea, *D'Orbigny.*

Pl. XI., fig. 5.

1850. 'Prodromus,' vol. i. p. 234.
Syn. 1836. *Nucula elliptica.* Römer. 'Ool. Geb.' p. 100.
1858. *Nucula inflexa.* Quenstedt. 'Jura,' t. xiii. f. 41, p. 110; t. xxiii. f. 15, p. 187.
1855. *Nucula cymbula* and *N. dura.* Simpson. 'Foss. Y. L.' p. 115.
1855. *Amphidesma nitidum*, p. 126.
1870. *Leda Quenstedti.* Tate. 'Irish Lias Foss.' p. 19, t. i. f. 4.

A common fossil throughout the Lower and Middle Lias, but attains considerable dimensions in the ironstone bands at Hawsker—a breadth of ⅘ths inch. Our drawing is not typical.

Geological position.—Zones of *Am. angulatus*, Coatham Marsh, Redcar; *Am. Bucklandi*, Redcar, Marske Bay, Robin Hood's Bay; *Am. oxynotus*, Robin Hood's Bay; *Am. Jamesoni*, Huntcliff, Robin Hood's Bay, Wood End, Warter, Langbargh; *Am. capricornus*, Huntcliff; *Am. magaritatus*, Staithes, Huntcliff, Danbydale; *Am. spinatus*, Hawsker (common), Kettleness, Grosmont; *Am. annulatus*, S. of Whitby, Grosmont, and N.W. Cleveland.

Leda Heberti, *Martin.*

1860. 'Pal. de la Côte-d'Or,' t. iii. fs. 1–4, p. 79.

Geological position.—Zone of *A. oxynotus*, Robin Hood's Bay (1 ex.).

Leda Zieteni, *Brauns.*

1871. 'Untere Jura im Nörd. Deutschland,' p. 373.
Syn. 1832. *Nucula inflata.* Zieten. 'Verst. Würt.' t. lvii. f. 4 (non Sow.).
1837. *Nucula acuminata.* Goldfuss. 'Pet. Germ.' t. cxxv. f. 7 (non Ziet.).

Shells agreeing in form with *N. acuminata*, Goldfuss, are confined to the lower beds of the Middle Lias, and though a somewhat similar species occurs in the middle portion of the formation, yet I cannot connect the two by intermediate passages. Should, however, the two be identical, then Simpson's name of *L. minor* has priority of publication.

Geological position.—Zone of *Am. Jamesoni*, Upsall Pit, Huntcliff, Peak, Robin Hood's Bay; and 1 example in the region of *A. armatus*, Robin Hood's Bay.

Leda minor, *Simpson.*

Pl. XI., fig. 9.

1855. (*Nucula.*) 'Foss. Y. L.' p. 115.

Shell subtriangular, globose; inflated in the umbonal region;

umbones very prominent, subcentral; anterior side inflated and rounded; pallial border arched; posterior side acuminated, short and rostrated. Surface concentrically striated.

Dimensions of largest example—breadth, $\frac{11}{32}$ths; length, $\frac{8}{32}$ths; thickness, $\frac{7}{32}$ths of an inch. This species, which is somewhat intermediate in form between *L. lachryma* and *L. ovum*, was described by Simpson as "very similar in form to *L. ovum*, but much smaller and not so wide in proportion; posterior side shorter, and without striæ." It differs from *L. Zieteni* (*L. acuminata*, Goldfuss) in its inflated form, not elliptical, and short rostral prolongation. I have specimens from the *Jamesoni*-beds of Aston Magna and Cheltenham, from those of *A. capricornus*, at Mickleton, and from the *spinatus*-beds at Fontaine-Etoupe-four.

Geological position.—Zones of *Ammonites capricornus*, Staithes, Hummersea, and Huntcliff (in the oyster bands abundant); *Am. margaritatus*, Staithes, Huntcliff (common), West Thormanby; *Am. Jamesoni*, Warter, Robin Hood's Bay.

Leda ovum, *Sowerby*.

1824. *Nucula ovum*. Sowerby. 'Min. Con.' t. cccclxxvi. f. 1.
1829, 35, 75. *Nucula ovum*. Phillips. 'Geol. York.' t. xii. f. 4.
1855. *Nucula ovum*. Simpson. 'Foss. Y. L.' p. 115.
Syn. 1822. *Arca rostrata*. Young and Bird. 'Geol. Surv.' t. viii. f. 24, p. 231.
1829. *Nucula complanata*. Phillips. 'Geol. York.' t. xii. f. 8.

This well-known shell of the Alum Shale was first figured by Parkinson in 1811, but without a specific name. Young and Bird's figure of it is a fair representation; but as Montague had described in 1803 an *Arca rostrata*, the two species being congeneric, their name must give place to the later one of Sowerby. The example figured in the Mineral Conchology was obtained at Whitby.

Phillips's *N. complanata* is a cast of *L. ovum*.

Geological position.—In great profusion in that portion of the Upper Lias formerly worked for alum; all the coast sections; Slapewath, Guisbro'?

Leda Renevierei, *Oppel*.

Pl. XI., fig. 4.

1856. 'Die Juraformation,' p. 95.
1870. Tate. 'Irish Liassic Foss.' p. 19, t. 1, f. 3.
Syn. 1856. *Leda tenuistriata*. Piette. 'Bull. Soc. Géol. de France,' t. x. f. 4, p. 206.
1865. *Leda tenuistriata*. Terquem and Piette. 'Lias Inf.' t. xi. f. 8, p. 89 (non *L. tenuistriata*, Sow., nec Münster).

It is unfortunate that the name applied to this species by Piette was pre-occupied, as his figure and description distinctly

set forth its characters. Oppel's diagnosis leaves us in doubt as to its correct interpretation; it reads: "Resembles *L. complanata*, Goldfuss, but does not attain the same size, and the anterior prolongation is shorter." The shell, which I represented, *loc. cit.*, t. i. f. 3, as agreeing the best with Oppel's description, differs but slightly from the ordinary form of *L. tenuistriata*, Piette, and must be regarded as an immature example. The Yorkshire examples do not differ from Piette's type.

Geological position.—Zone of *Am. angulatus*, Redcar; *A. Bucklandi*, Redcar, Marske Bay, and Robin Hood's Bay.

Leda texturata, *Terquem and Piette.*

Pl. XII., fig. 8.

1865. Terquem and Piette. 'Lias Inf. de l'Est de la France,' t. xi. fs. 5-7, p. 89.

This species agrees with the last, of which it may only be a variety; it is distinguished by the wrinkled concentric and oblique striæ which ornament the whole surface. In one specimen the striæ diverge from the umbo, and are interrupted by others which are oblique, producing an ornament like that of the surface of engine-turned watch-cases.

Geological position.—Zones of *Am. angulatus*, Redcar, Cliff; *Am. Bucklandi*, Redcar.

Leda v-scripta, *Tate.*

1870. 'Irish Lias. Foss.' t. i. f. 5, p. 19.

Its claim to specific rank is weak, as its resemblance to *L. texturata* is great, and its characteristic ornament may be only an exaggeration of that of the same species; the medial portion of the shell has slender plications *en chevron*, and the extremities are marked with oblique plaits; nevertheless, the identity is not proved, any more than that of *L. Renevieri* and *L. texturata*, though the association of the three under one specific name may yet have to be adopted.

Geological position. — Zone of *Am. angulatus*. Redcar (2 examples).

Leda complanata, *Goldfuss.*

1837. *Nucula complanata*. Goldfuss. 'Petref. Germ.' t. cxxv. f. 11.
Syn. 1855. *Nucula complanata*. Simpson. 'Foss. Y. L.' p. 116.

Geological position.—Zone of *Am. Jamesoni*, Osborne Rush Pit, near Upsall; High Stone, Redcar.

Leda graphica, *Tate.*

Pl. XIII., fig. 4.

1870. 'Quart. Jour. Geol. Soc.' vol. xxvi. t. xxvi. f. 12.
Syn. 1855. *Nucula longicaudata.* Simpson. 'Foss. York.' p. 115.

This species stands in the same relation to *L. complanata* that *L. texturata* does to *L. Renevieri*. *N. longicaudata* is a cast, and is presumably that of *L. graphica*, which occurs in the same series of strata.

An example, with the rostral prolongation incomplete, measures a line more than 1½ inches in width.

Geological position.—Zone of *Am. margaritatus*, Staithes (not rare), Hawsker; *A. spinatus*, Kettleness, Hawsker; *A. capricornus*, Staithes, Huntcliff.

Trigonia literata, *Young and Bird.*

1822. *Trigonia literata.* Young and Bird. 'Geol. Surv.' p. 225, t. viii. f. 2.
1829. *Trigonia literata.* Phillips. 'Geol. York.' t. xiv. f. 11, 3rd edit. pl. xii. fig. 10.
1855. *Trigonia literata.* Simpson. 'Foss. Y. L.' p. 116.

The original representation of this species is very rough, but the description is faithful. Phillips has quoted it from the Lower Shale at Robin Hood's Bay, as well as from the Alum Shale. The former statement is doubtless a clerical error, as it has not occurred to any other collector below the upper part of the Alum Shale, and he has since corrected the statement.

Geological position.—Zones of *Am. Jurensis*, Peak; and *A. communis* (in the upper part), Peak, Whitby, Lofthouse.

Trigonia lingonensis, *Dumortier.*

Pl. XI., fig. 2.

1869. 'Dépôts Jurassiques du Rhône,' p. 275, t. xxii. fs. 6–8.
1875. Phillips. 'Geol. York.' 3rd ed. t. xiv. fig. 11.
1876. Lycett. 'Foss. Trigoniæ,' t. xxii. figs. 1–4.

I announced ('Geol. Mag.,' vol. ix.) in 1872 the occurrence of this species in the main seam of ironstone in Cleveland, but it was known to Mr. Charlesworth in 1858, who had labelled a specimen in the York Museum, coming from the ironstone near Marske, as a new species of Trigonia.

Geological position.—Only known in the richer portion of the main seam in N. W. Cleveland, Skinningrove, Guisborough, Eston, &c. Many examples observed, and, with but one exception, as separated valves.

Trigonia ? modesta, *Spec. nov.*

Pl. XII., fig. 4.

Shell small, subtrigonal, depressed, umbones antemedial:

obliquely carinated; transversely costated; posterior area narrow, flattened, and transversely striated. The costæ are smooth, numerous, curved, and slightly bent downwards as they approach the subacute carina, which they do not reach. This costated Trigonia resembles *T. exigua*, Lycett, from the Inferior Oolite, as also the Rhætic *T. postera*, and is more regularly and strongly costated than *T. lingonensis* of the same size.

Dimensions.—Breadth, $\frac{2}{10}$ths of an inch; length, nearly $\frac{2}{10}$ths of an inch.

Geological position.—Zone of *Am. armatus*. Warter and Robin Hood's Bay. (Two incomplete and ill-preserved specimens.)

Astarte cingulata, *Terquem.*

1855. 'Pal. de Hettange,' t. xx. f. 6.

Geological position.—Zone of *Am. angulatus*, Cliff, Redcar, and Slake's Pit, Coatham; and *Am. Bucklandi*, Redcar.

Astarte obsoleta, *Dunker.*

1848. 'Paleont. I.' t. xxv. fs. 8, 9, p. 178.
Syn. 1850. *Astarte Gueuxii.* D'Orbigny. 'Prod. I.' p. 216.
1858. *Astarte psilonoti.* Quenstedt. 'Jura,' p. 45, t. iii. f. 14.

The figures of *Astarte obsoleta*, Dunk., represent a very small shell, which proves to be the young state of *Astarte Gueuxii.* Andler calls it *A. pusilla*, and Rolle, *A. Suessi*. *A. eryx*, D'Orb., *A. consobrina*, Chap. and Dew., and *A. dentilabrum*, Etheridge, are identical with *A. Gueuxii*. Quenstedt's *A. psilonoti* and *A. thalassina* are mere varieties of the same. It occurs throughout the Lower Lias in Yorkshire, but is abundant only in the *angulatus* and lower *Bucklandi*-beds.

Geological position.—Zones of *Am. planorbis*, Eston Gypsum Pit; *Am. angulatus*, Redcar and neighbourhood, Eston Pit, Millington, Cliff; *Am. Bucklandi*, Redcar, Marske Bay; *Am. oxynotus*, High Stones Redcar.

Astarte Oppeli, *Andler.*

Pl. XII., fig. 3.

1858. 'Neues Jahrbuch für Min.' p. 642.
Syn. 1865. *A. Saulensis.* Terquem and Piette. 'Lias Inf.' p. 74, t. vi. fs. 25, 26.

This, the largest of our Liassic Astartes, is very like *A. obliqua* of the Lower Oolite; one example measures $2\frac{1}{10}$ inches in breadth, and the same in length from the umbo to the posterior angle. It may be an aged form of *A. obsoleta;* but an adverse circumstance is, that it does not occur in all stations with that species.

Geological position.—Zone of *Am. angulatus*. Redcar and Millington (40 examples observed).

Astarte striato-sulcata, *Römer*.

Pl. XI., fig. 7.

1836. 'Norddeutsche Ool. Gebirge,' t. vii. f. 16, p. 112.
Syn. 1858. *A. amalthei*. Quenstedt. 'Jura,' t. xxiii. fs. 12, 13, p. 188.

Two forms of this shell are distinguishable: (*a*) one inflated, with few much-elevated and striated concentric plications; (*b*) the other compressed, rather projecting in front, with numerous slender plications, or finely striated.

Phillips records his *Astarte minima* from calcareous nodules in the Lias, as well as from the Inferior Oolite; it is highly probable that the Liassic examples belong to the present species.

Geological position.—Zones of *A. Jamesoni*, Huntcliff, Peak (form *a*, rare), Langbargh; *A. capricornus*, Huntcliff; *A. margaritatus*, Hawsker, Huntcliff; *A. spinatus*, Grosmont, Hawsker, Kettleness, Hob Hill, Upleatham, and Eston Mines, Hotham, (both forms; form *b* more abundant). *A. annulatus*, passim (form *b*).

Astarte rugata, *Quenstedt*.

1858. *Isocardia rugata*. Quenstedt. 'Jura,' t. xxiii. f. 26, p. 189.

Geological position.—Zone of *A. spinatus*. Eston (3 exs.).

Cardita Heberti, *Terquem*.

1855. 'Pal. de Hettange,' t. xx. f. 10.

Geological position.—Zones of *Am. angulatus*, Cliff, Millington, Redcar; *A. Bucklandi*, Redcar, Marske Bay. A common fossil at Redcar.

Cardita multicostata, *Phillips*.

Pl. XII., fig. 7.

1829. *Cardium multicostatum*. Phillips. 'Geol. York.' t. xiii. f. 21.
1855. *Cardium multicostatum*. Simpson. 'Foss. York. Lias.' p. 120.
Syn. 1867. *Cardita liasina*. Moore. 'Mid. and Up. Lias,' t. vii. f. 9, p. 98.

This shell has received seven specific denominations, and has been referred to the genera *Cardium*, *Isocardia*, *Astarte*, and *Cardita*. It is most certainly congeneric with *Cardita Heberti*; and if my interpretation of the internal parts be correct, it is rightly placed under *Cardita*. The majority of the specimens that have passed through my hands agree in shape with

Phillips's type; but others, and especially those from the *Jamesoni*-beds, are more or less compressed and carinated, and have the aspect of an *Opis*; narrower examples agree with *Isocardia angulata*, Goldfuss.

Geological position.—Zones of *Am. Jamesoni*, Huntcliff (rare); *Am. margaritatus*, Huntcliff, Staithes (common), East Thornaby, Hawsker; *Am. spinatus* (rare), Hob Hill, Upleatham, and Eston Mines.

Cardinia crassiuscula, *Sowerby*.

Pl. XIV., fig. 4.

1817. *Unio crassiusculus*. Sowerby. 'Min. Con.' t. 185.

This species seems hitherto to have been known only from adult examples, though Strickland conjectured that *C. elliptica*, Ag., was the young of it. After close study of many specimens of a *Cardinia*, having considerable resemblance to *C. hybrida*, I conclude that they are the young shells of *C. crassiuscula*. A few examples of intermediate size, depressed, and of a circular outline, conclusively establish that the shapes so extremely different really represent different stages of growth of the one species. An early stage of it is shown by Pl. XIV., fig. 4, but many figures would be requisite to illustrate its life-history. The irregular curve of the dorsal margin, or hump-backed appearance, is a readily distinctive character by which to separate it from *C. Listeri* and its varieties.

Geological position.—Zones of *A. Bucklandi*, Redcar and Marske (many examples), Robin Hood's Bay (Strickland), Ellerbeck; *A. angulatus*, ? near Pocklington (Phillips), Millington, Cliff.

Cardinia Listeri, *Sowerby*.

1817. (*Unio*.) 'Min. Con.' t. cliv. fs. 1, 3, and 4.
Var. *hybrida*, *Unio hybrida*. Sow. 'Min. Con.' t. cliv. f. 2.

Geological position.—Zones of *Am. angulatus*, Redcar, Eston, and Slakes Pit, Millington, Cliff; *A. Bucklandi*, Redcar, Ellerbeck, Robin Hood's Bay; *Am. oxynotus*, Robin Hood's Bay.

Cardinia concinna, *Sowerby*.

1819. (*Unio*.) 'Min. Con.' t. ccxxiii. fs. 1, 2.
Syn. 1842. *Pachyodon lanceolatus*. Stutchbury. 'Ann. Nat. Hist.' vol. viii. woodcut, p. 484.

Phillips records this species from the Upper Shale and Marlstone, but no description or figure is given, and it is highly probable that some other shell has been mistaken for it. The type of Stutchbury's *C. lanceolata* is from the Lower Lias, Robin Hood's Bay; several of our examples from Redcar agree with

but the passages to less elongated forms of *C. concinna* satisfy me of its invalid claims to specific rank. Young shells, such as Chapuis and Dewalque have figured under the name of *C. porrecta*, are not unfrequent in the middle beds of the *Bucklandi*-series at Redcar; whilst very old examples, comparable with *C. copides*, De Ryckholt, are rare.

Geological position.— Zone of *Am. Bucklandi*, Redcar, Robin Hood's Bay. (Stutchbury.)

Cardinia ovalis, *Stutchbury*.

1842. (*Pachyodon.*) 'Ann. Nat. Hist.' vol. viii. t. x. fs. 17–19.

Geological position.—Zones of *Am. planorbis*, near Northallerton; *Am. angulatus*, Redcar and Slake's Pit, Eston Gypsum Pit, Cliff.

Cardinia Deshayesi, *Terquem*.

1855. 'Pal. de Hettange,' t. xix. f. 6, p. 299.

Geological position.—Zone of *Am. angulatus*. Cliff.

Cardinia Desoudini, *Terquem*.

1855. 'Pal. de Hettange,' t. xx. f. 6, 1, p. 300.

Geological position.—Zone of *Am. angulatus*. Cliff.

Cardinia attenuata, *Stutchbury*.

1842. *Pachyodon.* 'Ann. Nat. Hist.' vol. viii. t. x. fs. 13, 14, p. 485.
Syn. 1815. *Cardinia lanceolata.* Agassiz. 'Et. Crit. Myes,' &c. t. xii. fs. 1–3.

Geological position.—*Am. Jamesoni* zone, Huntcliff (3 exs.).

Cardinia antiqua, *Phillips*.

1829. *Pallastra antiqua.* Phillips. 'Geol. York.' t. xiii. f. 16 (also called in letterpress *P. prototypa*).

Examples, showing the interior, which have been identified with Phillips's type, preserved in the York Museum, prove that this shell is a *Cardinia*, as conjectured by Agassiz, and catalogued as such by D'Orbigny in 1850. Both Strickland and Simpson are wrong in placing it under *C. crassiuscula*, from which it is widely removed. The shell is cuneiform, anterior side very short, lunule small; laminæ of growth, thick, imbricating, and few. Height, ¾ inch; length, 1¼ inch; thickness, ½ inch.

Geological position.—Sandstone of the zone of *Am. margaritatus*, Huntcliff, Staithes (not rare).

Cardinia lævis, *Young and Bird.*

Pl. XI., fig. 12.

1828. (*Cardita.*) 'Geol. Sur.' p. 226, t. vii. f. 14.
1855. (*Isocardia.*) Simpson. 'Foss. Y. L.' p. 119.

Shell trigonal, compressed, subequilateral; umbones acute, incurved, prominent, and approximate; surface concentrically plicated and striated; the striæ numerous, lunule deep. Dimensions: height, $1\frac{5}{12}$ inch; breadth, $1\frac{7}{12}$ inch; thickness, 1 inch.

Small examples of a *Cardinia*, considered to be the young of this species, have close agreement with *C. fascicularis*, Buv., but seem to be more excavated in front; the thick plications are grouped in twos and threes as in that species.

Young and Bird's figure represents a more orbicular shell than any to which I have applied their name; and it, moreover, contradicts their statement that the shell is remarkably smooth; but they add that in a few specimens "a few of the concentric lines of growth are rather prominent." The plications and striæ vary in strength, but in all my specimens there is no approach to absolute smoothness; nevertheless, I think that they are correctly identified with Young and Bird's species.

Geological position.—Zones of *Am. spinatus*, Eston, Upleatham, Hob Hill, Skinningrove, Slapewath, Belman and Glaizedale Mines; *Am. margaritatus*, upper beds, Staithes (1 ex.).

Cardinia crassissima, *Sowerby.*

1818. (*Unio.*) 'Min. Con.' t. cliii.

A cast probably of this species has been obtained from the main seam of ironstone, Hob Hill Mines, Saltburn.

Cypricardia cucullata, *Münster.*

1843. *Cardium cucullatum* in Goldfuss. 'Petref. Germ.' t. cxliii. f. 11. p. 218.
Syn. 1855. *Cardium securiforme.* Simpson. 'Foss. Y. L.' p. 120.
1855. *Arca securiformis*, id. p. 114.
1867. *Cypricardia intermedia, pellucida.* Moore. 'Mid. and Up. Lias,' t. vii. fs. 5, 6, pp. 99, 100.

Associated with small shells, comparable with *C. cucullata*, Münster, are larger ones, varying in shape, agreeing with *C. intermedia* and *C. pellucida*, Moore; intermediate forms connect them all together. *C. securiforme*, Simpson, is undoubtedly Münster's species, whilst *Arca securiformis* of the same author is a cast.

Geological position.—Zones of *Am. Jamesoni*, Chop Gate Bilsdale; *Am. margaritatus*, Staithes, Hawsker; *Am. spinatus*, Eston, Upleatham, and Hob Hill Mines, Staithes; *Am. annulatus*, Hob Hill, Skelton Park Pit.

Hippopodium ponderosum, *Sowerby*.

1819. Sowerby. 'Min. Con.' t. ccl.
1828. Young and Bird. 'Geol. Sur.' t. vii. f. 13, p. 227.
1855. Simpson. 'Foss. Y. L.' p. 119.
Syn. 1828. Young and Bird. 'Geol. Sur.' t. vii. f. 4, p. 221.
1855. Simpson. 'Foss. Y. L.' p. 118.
1855. *Mytilus rusticus*, *Mytilus hippocampus*, and *M. similis*. Simpson, *loc. cit.* p 118.
1875. *Hippopodium ferri*. Etheridge. 'Quart. Jour. Geol. Soc.' vol. xxxi. t. v. f. 6, p. 127.

The results of a careful comparison of numerous examples of *Hippopodia*, in various stages of growths, from the Lower and Middle Lias of Yorkshire, are that *Mytilus hippocampus* is not different from *Hippodium ponderosum*, and that the shell is of variable shape: elongated, oblong, and nearly square; and, moreover, varies in the amount of convexity, rugosity of surface, and in the extent of the anterior margin. Young and Bird's figure of *M. hippocampus* represents a cast, and seemed at first to present as distinctive characters an oblong form, and a prolonged or apiculate anterior side; but they are not constant, and are occasionally presented by specimens from the lower beds of the Lower Lias. Some of these latter agree with *Cypricardia compressa*, Terq.; and *Cypricardia Falsani*, Dumort., may be the same.

Geological position.—Zones of *Am. angulatus*. Redcar and Eston Gypsum Pit (3 exs.).; *A. Bucklandi*, Redcar, Marske Bay (abundant), and Robin Hood's Bay; *A. oxynotus*, Robin Hood's Bay, High Stone, Redcar; *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham Scars; *A. capricornus*, Staithes, Hummersea, Huntcliff (common); *A. margaritatus*, Staithes, Huntcliff, frequent in the Sandstones (common); *A. spinatus*, Upleatham and Slapewath Mines (2 exs.).

Young and Bird record their *M. hippocampus*, from the Kettleness bands.

Hippopodium gigas, *Spec. nov.*

Pl. XIII., fig. 5.

Shell short and massive, ovately-trigonal, excessively gibbous; umbones very large, inflated, incurved, approximate, directed forwards, and nearly reaching the plane of the anterior margin; lunule deep, cordiform; anterior side very short, rounded; front margin slightly curved; posterior side sloping, rounded at the margin; surface covered with depressed concentric plications and striæ; plications imbricating towards the front margin. Dimensions: breadth, 5 inches; height, $3\frac{3}{4}$ inches; greatest thickness, $2\frac{3}{4}$ inches.

Geological position.—Zone of *Am. spinatus*, Hub Hill, Upleatham. Belman and Eston Mines (9 exs.).

Myoconcha inclusa, *Terquem*.

1855. (*Cyprioardia.*) 'Pal. de Hettange,' t. xx. f. 12, p. 305.
1865. (*Myoconcha.*) Terquem and Piette. 'Lias Inf.' &c. p. 85.

A single specimen from the *angulatus*-beds, Millington. May it not be a young form, of which *M. psilonoti* is the adult?

Myoconcha psilonoti, *Quenstedt*.

1858. 'Jura,' t. iv. f. 15.

Geological position.—Zones of *Am. angulatus*, Cliff, Redcar; *Am. Bucklandi*, Redcar and Marske Bay.

Myoconcha decorata, *Münster*.

1837. *Mytilus* in Goldfuss. 'Petref. Germ.' t. cxxx. f. 10, p. 174.
Syn. 1828. *Solen ensis*. Young and Bird. 'Geol. Sur.' p. 220.
1855. *Mytilus ensis*. Simpson. 'Foss. Y. L.' p. 118.

Young and Bird's "*Solen ensis*, or a species near akin to it," proves to be the cast of *Myoconcha decorata*. Oppel seems to have met with a like fossil, and equally to have misunderstood it, as he states, in a note to his *Solen liasinus*, that a similar form was found by him in the Marlstone of Yorkshire.

Geological position.—Zones of *Am. capricornus*, Scugdale Beck, near Huthwaite Green, Staithes; *Am. spinatus*, Hutton, Grosmont, Hawsker.

Tellina lingonensis, *Dumortier*.

1869. 'Dépôts Jurassiques,' vol. iii. t. xxx. f. 1, p. 263.

Geological position.—Zone of *A. spinatus*, Hummersea (1 ex.).

Tellina fabalis, *Simpson*.

Pl. XII., fig. 5.

1855. 'Fossils of the Y. L.' p. 121.

Shell ovate-trapezoid, depressed, equivalve, inequilateral, concentric striæ numerous and fine; the surface of the cast shows obsolete ridges radiating from the umbo. Breadth, $\frac{4}{10}$ inch; height, $\frac{3}{10}$ inch.

Geological position.—Zones of *Am. spinatus*, Hawsker (3 exs., one in the Whitby Mus.); *A. margaritatus*, Staithes (1 ex.).

Venus tenuis, *Koch and Dunker*.

1837. 'Beiträge, Nord. d. Ool.' p. xxx. t. ii. f. 5.
Syn. 1855. *Tellina cycliformis*. Simpson. 'Foss. Y. L.' p. 121.

Geological position.—Abundant in the zone of *Am. Jurensis*,

Peak; and occurs in the *Lingula*-bed at Blea Wyke. Its range in N. W. Germany is from the *opalinus*-beds to the Great Oolite.

Isodonta Ewaldi, *Bornemann.*

1854. (*Tæniodon.*) 'Lias b. Göttingen,' p. 66.
Syn. 1858. *Opis cloacinus.* Quenstedt. 'Jura,' t. i. fig. 35.
1861. *Axinus cloacinus.* Moore. 'Quart. Jour. Geol. Soc.' vol. xvii. t. xv. f. 16.

Casts probably of this species, which have been called ***Pullastra arenicola*** by the Gloucestershire geologists, are common in Rhætic shales and sandstones about Northallerton and Thornton-le-Moor; specimens with the test were obtained associated with *Cassianella contorta*, from the Eston Gypsum Pit by Mr. G. Lee.

Protocardium truncatum, *Sowerby.*

1827. (*Cardium.*) 'Min. Con.' t. dliii. f. 3.
1829. (*Cardium.*) Phillips. 'Geol. York.' t. xiii. f. 14.
Syn. 1822. *Cardium pectinatum, triangulare.* Young and Bird. 'Geol. Sur.' t. viii. f. 5.
1828. *C. deltoideum.* Young and Bird. Id. t. viii. f. 5.

This widely-spread shell of the Middle Lias was noticed first by Young and Bird as one akin to '*C. pectinatum;*' but later, regarding it as distinct, they gave a faithful description of it under the head of *C. deltoideum;* Sowerby in the meanwhile published it under the name it now universally bears.

Geological position.—Throughout the whole Middle Lias: most abundant, and largest in the oyster-bands of the *capricornus*-series and in the *margaritatus*-sandstones; in the latter constituting shell-beds of wide extent. Average-sized specimens have a length of 1 inch, and a breadth of 1¼.

Zones of ***Am. Jamesoni***, Robin Hood's Bay, Coatham, Langbargh; ***Am. capricornus***, on the coast; ***Am. margaritatus***, on the coast and inland (passim); ***Am. spinatus***, not common, but general; ***Am. annulatus***, Skelton Park Pit, Hob Hill, Staithes.

Protocardium sub-striatulum, *D'Orbigny.*

1850. (*Cardium.*) 'Prod. I.' p. 202.
Syn. 1829. *Cardium striatulum.* Phillips. 'Geol. York.' t. xi. f. 7 (non Brocchi).

A gibbous *P. truncatum*, with a broader and less abruptly posterior area. Originally described from Inferior Oolite-specimens from Blea Wyke.

Geological position.—Zone of *A. Jurensis*, Peak.

Protocardium Philippianum, *Dunker.*

1847. (*Cardium.*) 'Palæontographica I.' t. xvii. f. 6. p. 116.
Syn. 1853. *Cardium Rhæticum.* Merian. 'Geol. Bemerk. u. d. Nördl. Vorarlberg,' t. iv. fs. 40 and 41, p. 19.

The characters relied on as distinguishing *P. Rhæticum* from *P. Philippianum* have not been found by me to be constant; their identity being established requires the employment of the earlier name. The examples from the *angulatus* and *Bucklandi* beds, which are few in number, are small; but those from oyster-bands and Rhætic are of considerable size.

Geological position. — *Rhætic.* Thornton-le-Beaus, Dibdale, near Northallerton, Eston Gypsum Pit. Zone of *Am. planorbis*, in the *Pleuromya* limestones and oyster-bands, Eston Gypsum Pit, Foxton, near Northallerton, Cliff, Hotham; *Am. angulatus*, Redcar, Cliff; *Am. Bucklandi*, Redcar, Robin Hood's Bay.

Protocardium oxynoti, *Quenstedt.*

1858. (*Cardium.*) 'Jura,' t. xiii. f. 46, p. 110.
Syn. 1855. *Arca ? triangularis.* Simpson. 'Foss. Y. L.' p. 114.

A very small species, related to the foregoing, but of a rounded form. Simpson's diagnosis wants definition, the generic characters being overlooked. Having examined the type, I have confidence in this identification.

Geological position.—Zone of *Am. oxynotus*, Robin Hood's Bay (abundant in the middle part); sub-zone of *A. armatus*, Robin Hood's Bay, Warter, Husthwaite.

Lucina limbata, *Terquem and Piette.*

1865. 'Lias Inf. de l'Est de la France,' t. x. fs. 6 and 7, p. 136.
Syn. 1855. *Tellina striata.* Simpson. 'Foss. Y. L.' p. 120.

By way of apology for suppressing Simpson's name, I urge the insufficiency of a mere verbal description of a shell, the generic position of which is not ascertained. In this case, though the terse diagnosis distinguishes *T. striata* from the two other species described from the Yorkshire Lias, yet it does not afford characters by which to separate it from other Liassic species previously referred to the genus.

Geological position.—Zones of *Am. angulatus*, Redcar and Cliff (rare); *Am. Bucklandi*, Robin Hood's Bay, Redcar, and Marske Bay (very abundant).

Lucina cardinoides, *Spec. nov.*

Pl. XVI., fig. 8.

Ovate-trapezoid, subinequilateral, subventricose, concentrically ridged; rounded in front, posteally subtruncated; ventral

margin curved; umbones small, antemedial, subacute; lunule very small; escutcheon linear.

Has the aspect of a *Cardinia*, especially of the young of *C. lævis*, Y. and B. The hinge is not known, but is referred to Lucina because of a certain resemblance it bears to *Lucina limbata*. Dimensions: breadth, ·7; height, ·55; thickness, ·35; anterior side, ·3 inch.

Geological position.—Zone of *Am. Bucklandi*, Redcar (3 exs.).

Lucina pumila, *Münster, sp.*

1837. (*Venus.*) Goldfuss. 'Petref. Germ.' p. 243, t. cl. f. 7.

Geological position.—Zone of *Am. spinatus*, Hawsker (1 ex.).

Unicardium cardioides, *Phillips.*

1829. (*Corbula.*) 'Geol. York.' t. xiv. f. 12.
1855. Simpson. 'Foss. Y. L.' p. 122.
Syn. 1855. *Corbula æquivalvis, deltoidea, inæquivalvis.* Simpson, *loc. cit.* pp. 123, 149.

There are good grounds for the belief that the type of *Corbula cardioides* is from the *Jamesoni*-beds of the Yorkshire coast, and specimens obtained therefrom by us are comparable with it, now preserved in the York Museum. The *Mactromya liasina*, Ag., which is considered by some authors as a distinct species, does not afford any good distinctive marks. The former is generally more transverse and equilateral; the latter somewhat globose and inequilateral; but after an examination of many examples from the *Jamesoni* and *Bucklandi* beds, I am forced to admit their identity. *U. Janthe*, D'Orb., is not distinct from *U. cardioides*. Simpson has made three additional species—his *C. æquivalvis* is undistinguishable from *U. cardioides*; his *C. deltoidea* is a very large example of the same; whilst his *C. inæquivalvis* is a specimen of *U. cardioides* with shifted valves.

Geological position.—Zones of *Am. angulatus*, Cliff, Redcar, Slake's Pit, Coatham, Eston Pit; *Am. Bucklandi*, Redcar, Marske Bay; *A. oxynotus*, High Stones Redcar; *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, High Stones Redcar.

Unicardium subglobosum, *Tate.*

1867. *Unicardium globosum.* Moore. 'Mid. and Up. Lias,' t. vii. f. 15, p. 103 (non Agassiz, 1843).

This species is distinguished from *U. cardioides* in its much more central umbones, less angular, and more rounded form; whilst it is strongly striated radially on the umbones.

Geological position.—Zones of *Am. spinatus*, above the main seam, Staithes, Kettleness; *A. annulatus*, S. of Whitby (an obscure specimen possibly of this species).

Tancredia ovata, *Chapuis and Dewalque.*

1853. 'Terr. Sec. de Lux.' t. xxv. f. 2, p. 173.
Syn. 1875. *Tancredia ferrea.* Etheridge. 'Quart. Jour. Geol. Soc.' vol. xxxi. p. 127, t. v. f. 4.

The original description of this species is exactly applicable to my specimens, which also agree with the drawing in form, size, and ornamentation.

Geological position.—Zone of *Am. Bucklandi.* Redcar.

Tancredia longicostata, *Buvignier.*

1852. (*Hettangia.*) 'Pal. Dépt. de la Meuse,' p. 15, t. xiii. fs. 19, 20.

Geological position.—Zone of *Am. spinatus*, Eston Mines (1 ex.).

Tancredia lucida, *Terquem.*

1853. *Hettangia lucida.* 'Bull. Soc. Geol. Fr. etc.' p. 375, t. ii. fs. 8–10.

A nearly perfect shell, but having much agreement with, though half as large again as, *T. lucida*, from the Main Seam, Upleatham.

Tancredia broliensis? *Buvignier.*

1852. (*Hettangia.*) 'Pal. Dépt. de la Meuse,' t. x. f. 22.
Syn. 1875. *Tancredia liassica.* Etheridge, *loc. cit.* t. v. f. 5.

Geological position.—Casts of a large ovately-trigonal shell, with a broader posterior area than *T. broliensis*, Buvignier, have been obtained from the "Black Hard," and from the main seam at Upleatham and Eston Mines.

Tancredia apicistria, *Rolle.*

1861. 'Sitz. der K. Akad. d. Wiss.' vol. xlii. p. 275, f. 7.

Geological position.—Zone of *Am. Bucklandi*, Redcar (7 exs.).

Tancredia dionvillensis, *Terquem.*

Pl. XIV., fig. 12.

1853. (*Hettangia.*) 'Bull. Soc. Géol. de la France,' vol. x. p. 375, t. i. fs. 1–4.

In the Whitby Museum is a *Tancredia* with the two valves in contact along the dorsal line, but separated below, and deprived of the extremity of the rostral prolongation. Its shape is that of *T. dionvillensis*, though much larger; some slight differences in the relative proportions of different parts are noticeable, but they are not of such magnitude as to justify a new denomina-

tion. The dimensions are: length, 2½ inches; length of posterior side, 1½ inch; height, 1¼ inch.

Geological position.—Zone of *Am. serpentinus*, associated with *Posidonomya Bronni*, near Whitby (Whitby Museum); *Am. communis*, Lofthouse Alum Works (a cast). The type is from the *A. opalinus*-beds of Thionville.

Pholadomya glabra, *Agassiz.*

1842. 'Et. Critiques, etc.—Myes.' t. iii. fs. 12–14, p. 69.

Geological position.—Zones of *Ammonites angulatus*, Cliff, Slake's Pit, Coatham; *A. Bucklandi*, Redcar, Marske Bay, Nunthorpe, Robin Hood's Bay.

Pholadomya Fraasii, *Oppel.*

1856. 'Juraformation,' p. 95.
Syn. 1858. *P. prima.* Quenstedt. 'Jura,' t. 5, fig. 2.

Geological position.—Zones of *A. angulatus*, Cliff; *A. Bucklandi*, Redcar.

Pholadomya decorata, *Zieten.*

1832. 'Verst. Würt.' p. 87, t. xlvi. f. 2.
Syn. 1855. *P. antiquata*, *P. elongata*, *P. truncata*. Simpson. 'Foss. Y. L.' p. 129.

Geological position.—Sub-zone of *Am. armatus*, Robin Hood's Bay, High Stones Redcar. One of the most common and characteristic fossils of the *Jamesoni*-beds, Robin Hood's Bay, Huntcliff, Coatham, Normanby Drift, Chop Gate, Bilsdale.

Pholadomya Beyrichii, *Schlönbach.*

1863. 'Zeitschr. d. D. Geol. Ges.' vol. xv. t. xiii. f. 1, p. 537.

Geological position.—Zone of *Am. capricornus*, Huntcliff (2 exs.), Hawsker (1 ex.).

Pholadomya ambigua, *Sowerby.*

1819. (*Lutraria.*) 'Min. Con.' t. ccxxii.
Syn. 1855. *P. producta*, *P. recurva.* Simpson. 'Foss. Y. L.' pp. 127–129.

P. recurva, Simpson, is not separable from *P. ambigua*, whilst *P. producta* is an aged specimen.

Geological position.—Zone of *Am. Jamesoni*, Robin Hood's Bay; *A. capricornus*, Hummersea; *A. margaritatus*, Huntcliff, Hummersea (rare). A common fossil in the main seam of ironstone, where it attains very large dimensions, N. W. Cleveland, Staithes, Kettleness, Glaizedale; *Am. annulatus*, Skelton Park Pit (one imperfect example).

Pholadomya Simpsoni, *Tate.*

Pl. XII., fig. 1.

1855. *Pholadomya gibbosa.* Simpson. 'Foss. Y. L.' p. 128 (non Sow.).

Shell ovately triangular, the ventral margin much arched and strongly incurved behind the umbones; umbones nearly terminal, incurved, obtuse; escutcheon very large; surface ornamented with about 7 oblique diverging and nodulose ribs, and with concentric folds and striæ.

This species is somewhat intermediate in form between *P. decorata* and *P. ambigua*, being triangular, with a very short anterior side, but produced and rather pointed posteriorly; the ribs are commonly 7 in number, strong, and nodulated.

Dimensions.—Height, 2 inches; breadth, 2½ inches; thickness, 1¼ inch.

Geological position.—Zone of *Am. spinatus.* From the shales between the main Ironstone Seam and the "Grey Shales" at Kettleness, Staithes, Park Wood, and Rockcliff.

Pholadomya lunata, *Simpson.*

1855. 'Foss. Y. L.' p. 128.

Transversely oval, elongated; umbones gibbous, very large, ante-medial; anterior side produced, inflated; margin regularly rounded, front margin much curved; posterior side attenuated, elongated, obtusely pointed; dorsal line deeply incurved behind the umbones. Surface ornamented with 3 faint oblique ribs and concentric rugæ and striæ.

Dimensions of the type.—" Width, 5 inches; length, 3½ inches."

This species is separable from its congeners, by its elongated form, few ribs, and the deep saddle-like depression behind the umbones.

Geological position.— Zone of *Am. spinatus*, Cleveland Main Seam, Belman Mines (Mr. T. Allison), Hob Hill, and Eston Mines (Mr. G. Lee). (5 exs.) Locality and position of type in the Whitby Museum not ascertained.

Pholadomya ventricosa, *Agassiz.*

1844. (*Homomya.*) 'Et. Critiques, etc.—Myes,' t. xvi. fs. 7-9 and 17, p. 158.

Syn. 1855. *P. concinna.* Simpson. 'Foss. Y. L.' p. 128.

A fine example, comparable with Dumortier's figure of this species ('Dép. Jur.,' Pt. II. t. xviii., fs. 3, 4, p. 45), I obtained from the Upper *Bucklandi*-beds in Marske Bay; and the type of *P. concinna* is equally good, but the identity of the Robin Hood's Bay

ᴧ in the upper part of the
ᴧsis-beds at Peak.

, *Phillips.*

Geol. York.' t. xi. f. 42.
Simpson. 'Foss. Y. L.' p. 124.

from the Inferior Oolite of the
i. donaciformis, but is more ovate
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—Zone of *Am. Jurensis* and *Inferior Oolite*,

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Gresslya punctata, *Simpson.*

Pl. XIV., fig. 10.

1855. (*Amphidesma.*) 'Foss. Y. L.' p. 124.

"Subtriangular, transverse, beaks approximate incurved; anterior side short, angular, with a broad longitudinal constriction, posterior elongated (imperfect), transverse striæ numerous, dotted, or reticulated."—Simpson.

Dimensions.—Height, 2 inches; thickness, 1¼ inch; total length (estimated), 3½ inches. Length of anterior side, 1 inch.

This shell has some resemblance to *G. Seebachii*, but it is more oblong and less inflated; the broad depression proceeding from the umbo will separate it from all its allies, excepting *G. donaciformis*, which is of a different shape.

Geological position.—Sub-zone of *Am. armatus*, Robin Hood's Bay (1 ex. Whitby Museum).

The Gresslyas in the upper part of our Middle Lias have had several names applied to them. The extremes in shape are con-

specimens is not so satisfactory, as they are invariably in the state of casts, more or less distorted.

Geological position.—Zones of *Am. Bucklandi*, Redcar, Marske Bay, and Robin Hood's Bay; *A. oxynotus*, Robin Hood's Bay (common).

Goniomya heteropleura, *Agassiz.*

1845. 'Et. Crit. etc.—Myes,' t. i. fs. 9, 10, p. 24.
Syn. 1858. *Mya rhombifera.* Quenstedt. 'Jura,' t. x. f. 5. p. 82.

Geological position.—Zone of *Am. Bucklandi*, Redcar (1 ex.).

Goniomya hybrida, *Münster.*

1844. (*Lysianassa.*) Goldfuss. 'Petref. Germ.' t. cliv. f. 10, p. 263.
Syn. 1855. *Mya literata.* Simpson. 'Foss. Y. L.' p. 126.

Geological position.—Zones of *Am. Jamesoni*, Coatham (1 ex.); *A. margaritatus* (upper), Staithes, Marske Mill, Saltburn (many specimens); (*horizon?*) Robin Hood's Bay (Simpson); *A. spinatus*, Kettleness; *A. annulatus*, Skelton Park Pit (2 obscure impressions).

Gresslya Galathea, *Agassiz.*

1844. (*Pleuromya.*) 'Myes,' p. 239, t. xxviii. fs. 1–3.

Geological position.—Zones of *Am. angulatus*, Redcar (rare), Slake's Pit, Coatham; *A. Bucklandi*, Redcar and Marske Bay; *Am. oxynotus*, Robin Hood's Bay.

Gresslya striata, *Agassiz.*

1844. 'Myes,' p. 219, t. xiiic, fs. 7–9.
Syn. 1855. *Arca ? subtriangularis.* Simpson. 'Foss. Y. L.' p. 116.
1855. *Venus mediæva*, id. p. 122.
1855. *Amphidesma concavum*, id. p. 125.

Geological position.— Zone of *Am. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Langbargh.

Gresslya donaciformis, *Phillips.*

1829. *Amphidesma donaciforme.* Phillips. 'Geol. York.' t. xii. f. 5.
1855. *Amphidesma donaciforme et A. irregulare.* Simpson, *loc. cit.* p. 124.
Syn. 1828. *Donax sp.* Young and Bird, p. 224, t. vii. f. 12 (probably).

Well distinguished by the anterior longitudinal constriction. The largest specimen examined measures 2¼ inches in width and 1¼ inches in height.

A. irregulare is, I consider, a rather short and stout example of *G. donaciformis.*

Geological position.—A common fossil in the upper part of the Alum Shale, but also occurs in the *Jurensis*-beds at Peak.

Gresslya abducta, *Phillips.*

1829. *Unio abductus.* Phillips. 'Geol. York.' t. xi. f. 42.
Syn. 1855. *Amphidesma rotundatum.* Simpson. 'Foss. Y. L.' p. 124.

The type of this species is from the Inferior Oolite of the Yorkshire Coast; it resembles *G. donaciformis*, but is more ovate and inflated, is without the longitudinal constriction, and its posterior side is shorter and more rounded—characters given by Simpson for *A. rotundatum*, though the specimen perfectly agrees with Phillips's figure of *Unio abductus*, which may be identical with his *Amphidesma rotundatum*. A large specimen measures 2½ inches in breadth, 1¾ inch in height, and 1¼ inch in thickness.

Geological position.—Zone of *Am. Jurensis* and *Inferior Oolite*, Peak.

Gresslya rotundata, *Phillips.*

1829. *Amphidesma rotundatum.* Phillips. 'Geol. York.' t. xii. f. 6.

This species is unknown to us, if it be distinct from *G. abducta*, young examples of which agree very well with Phillips's figure of *A. rotundatum*. Agassiz considered it very closely allied to his *G. pinguis*, and probably identical with it; if so, then the species will stand.

It is quoted from the Upper Lias Shale, but no locality is given.

Gresslya punctata, *Simpson.*

Pl. XIV., fig. 10.

1855. (*Amphidesma.*) 'Foss. Y. L.' p. 124.

"Subtriangular, transverse, beaks approximate incurved; anterior side short, angular, with a broad longitudinal constriction, posterior elongated (imperfect), transverse striæ numerous, dotted, or reticulated."—Simpson.

Dimensions.—Height, 2 inches; thickness, 1¼ inch; total length (estimated), 3½ inches. Length of anterior side, 1 inch.

This shell has some resemblance to *G. Seebachii*, but it is more oblong and less inflated; the broad depression proceeding from the umbo will separate it from all its allies, excepting *G. donaciformis*, which is of a different shape.

Geological position.—Sub-zone of *Am. armatus*, Robin Hood's Bay (1 ex. Whitby Museum).

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specimens is not so satisfactory, as they are invariably in the state of casts, more or less distorted.

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Gresslya Galathea, *Agassiz.*

1844. (*Pleuromya.*) 'Myes,' p. 239, t. xxviii. fs. 1–3.

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Syn. 1828. *Donax sp.* Young and Bird, p. 224, t. vii. f. 12 (probably).

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The type of this species is from the Inferior Oolite of the Yorkshire Coast; it resembles *G. donaciformis*, but is more ovate and inflated, is without the longitudinal constriction, and its posterior side is shorter and more rounded—characters given by Simpson for *A. rotundatum*, though the specimen perfectly agrees with Phillips's figure of *Unio abductus*, which may be identical with his *Amphidesma rotundatum.* A large specimen measures 2½ inches in breadth, 1¾ inch in height, and 1¼ inch in thickness.

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1855. (*Amphidesma.*) 'Foss. Y. L.' p. 124.

"Subtriangular, transverse, beaks approximate incurved; anterior side short, angular, with a broad longitudinal constriction, posterior elongated (imperfect), transverse striæ numerous, dotted, or reticulated."—Simpson.

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This shell has some resemblance to *G. Seebachii*, but it is more oblong and less inflated; the broad depression proceeding from the umbo will separate it from all its allies, excepting *G. donaciformis*, which is of a different shape.

Geological position.—Sub-zone of *Am. armatus*, Robin Hood's Bay (1 ex. Whitby Museum).

The Gresslyas in the upper part of our Middle Lias have had several names applied to them. The extremes in shape are con-

siderable, but three types may be selected; and though no very good characters can be given, yet it may be convenient to call them under distinctive names. A series of transformations, commencing with a triangular shell, *G. lunulata*, conducts us through an ovate form, *G. Seebachii*, to an oblong or nearly cylindrical one, *G. intermedia*. The examination of a very considerable number of specimens in various stages of growth induces me to the belief that the distinctions I have established are fairly founded.

Gresslya lunulata, *Tate*.

Pl. XII., fig. 10.

Syn. 1855. *Pholadomya rostrata*. Simpson. 'Foss. Y. L.' p. 127 (non *G. rostrata*, Ag.).
1855. *Pholadomya rostellata*. Id. p. 127.

Transversely ovate, very oblique; umbones approximate, small, incurved, pointed, anterior; escutcheon large, cordate; anterior side short, truncated, posterior rounded and attenuated; transverse striæ numerous, irregular.

P. rostellata is founded on a crushed example of *P. rostrata*, which, as the specific name is occupied by a *Gresslya*, is here re-named.

Geological position.—Zone of *Am. margaritatus*, Hawsker, Staithes, Huntcliff. (Type in the Whitby Museum.)

Gresslya Seebachii, *Brauns*.

Pl. XIII., fig. 3.

1865. 'Palæontographica,' vol. xiii. p. 100.
Syn. 1864. *Gresslya ventricosa*. Seebach. 'Han. Jur.' t. vi. f. i. p. 128 (non Ag.).
1855. *Amphidesma maculatum*, *A. subtruncatum*, *A. læve*. Simpson. 'Foss. Y. L.' p. 125.
1829. ? *Pholadomya obliquata*. Phillips. 'York.' t. xiii. f. 15.
1829. *Unio abductus* (pars). Phillips. 'Geol. York.'

This is one of the commonest fossils in the *margaritatus*-beds, being of large size in the sandstones, attaining to a width of 3½ inches, and a height of 2 inches; it then agrees with Seebach's figure, except that our shell is more pointed posteriorly. In the Upper Marls it is of smaller size and less inflated, but is abundant; to this form Simpson has given the name *Amphidesma læve*, whilst his types of *A. maculatum* (which is slightly crushed) and *A. subtruncatum* are identical with the shell referred to *G. Seebachii*.

Crushed and distorted examples of this species so much resemble Phillips's figure of his *Pholadomya obliquata* that I am induced to place the name as a synonym under *Gresslya Seebachii*.

Pholadomya decorata, Zieten, has been considered identical with *P. obliquata*, Phillips, apparently on the grounds only of their obliquity; but the figure of the latter does not represent any radial ribs, and its resemblance to a *Gresslya* is greater than to a *Pholadomya*. Moreover, *P. decorata* does not occur in the Yorkshire "Marlstone," whence *P. obliquata* was obtained.

Seebach states that this species is known in England as *Myacites unioides*, but my experience leads me to differ from him, and to assert that *Pleuromya costata* is commonly called *Myacites unioides*.

It is probable that the *Unio abductus*, Phillips, quoted by that author from the Yorkshire "Marlstone," is this species.

Geological position.— Zone of *Ammonites margaritatus*, Huntcliff, Rockcliff, Staithes, Robin Hood's Bay, Roseberry, Stokesley Hills, &c.

Gresslya intermedia, *Simpson.*

Pl. XIII., fig. 8.

1855. *Amphidesma*, 'Foss. Y. L.' p. 125.
Syn. 1855. *Mya dubia*. Simpson, *loc. cit.* p. 126.
1855. *Pholadomya lævis*. Id. p. 128.
1829. ? *Amphidesma rotundatum* (pars). Phillips. 'Geol. York.'
Donax sp. Young and Bird, p. 224 (probably).

Simpson's *A. intermedium* is a type of the more frequently occurring, whilst his *M. dubia* is of larger growth, and comparable with specimens obtained abundantly at Hutton and Slapewath from the main and bottom seams of ironstone.

He characterises *A. intermedium* as intermediate in shape between *Amphidesma rotundatum* and *A. læve.* It resembles more *G. donaciformis*, from which it differs in the more elongated shape, curved front, less inflated umbones, small lunule, and in the absence of the longitudinal constriction.

Ordinarily-sized specimens measure 2½ inches in width, 1½ inch in height, and 1 inch thick; the largest, 3½ inches wide and 2 inches high.

Geological position.—One of the most abundant fossils in the Cleveland main seam of ironstone, occurring profusely in the N. W. mining district; also at Swainby, Grosmont, Sleights, Howdale, &c. Zone of *Ammonites margaritatus*, in the bottom seam of ironstone, especially at Slapewath and Hutton, in the position of life. Also Staithes, Grosmont, Hawsker.

Pleuromya liasina, *Schübler.*

1830. (*Unio.*) In Zieten's 'Verst. Würt.' p. 81, t. lxi. f. 2.

Geological position.—Zones of *Am. Bucklandi*, Redcar, Robin Hood's Bay; *A. angulatus*, Redcar.

Pleuromya crassa, *Agassiz.*

1843. 'Et. Crit. Myes, &c.' p. 240, t. xxviii. fs. 4–6.

Geological position.—Zone of *Am. Bucklandi*, Redcar.

Pleuromya ovata, *Römer.*

1839. (*Lutraria.*) 'Ool. Geb. Nachtr.' p. xli. t. xix. f. 27.
Syn. 1855. *Amphidesma ventricosum.* Simpson. 'Foss. Y. L.' p. 125.

Geological position.—Zones of *Am. armatus*, Robin Hood's Bay, High Stone, Redcar, Warter; *A. Jamesoni*, Robin Hood's Bay, Huntcliff, Coatham, Normanby Drift, Upsall Pit, Easby, Chop Gate, Bilsdale; *A. capricornus*, Huntcliff, Hummersea.

Pleuromya costata, *Young and Bird.*

Pl. XIII., fig. 9.

1828. (*Unio.*) 'Geol. Sur.' t. viii. f. 7, p. 223.
1855. (*Amphidesma.*) Simpson. 'Foss. Y. L.' p. 123.
Syn. 1855. *Mya ferruginea.* Simpson. Id. p. 126.
1855. *Myacites unioides.* Auctores, Anglicorum.

This common fossil in the *spinatus*-beds of Yorkshire, and of other parts of England and usually named *Myacites unioides*, is an elongated, deeply grooved, very inequilateral shell, resembling *P. liasina*, Schübler, and *P. unioides*, Röm., from which it is distinguishable by its short, truncated front. It presents considerable variation in shape.

That form which best agrees with *Unio costatus*, Y. and B., is confined to the main seam of ironstone and a few beds above it. At Staithes, Kettleness, and Hawsker, it is moderately high and inflated, not much attenuated behind, and deeply grooved. Young and Bird compare it with *Unio Listeri*, Sow., "exactly corresponding with it in form and size, but deeply and concentrically ribbed." Simpson describes it as "subtriangular, very inequivalve, beaks incurved, approximate, anterior side triangular; posterior side elongated and slightly recurved; base convex; transverse ribs numerous, strong, rounded, equal to intervening concave furrows transversely striated." Dimensions usually about 2 inches wide, 1¼ inch high, nearly 1 inch thick.

A more elongated and neater form with slender ribs abounds in the soft oolitic ironstone in the N.W. district; its average dimensions are, width 2 inches, height 1 inch, thickness ⅞ inch.

Another called *M. ferruginea* by Simpson connects the latter with the former, but attains to a large size; it is deeply grooved, but much produced and attenuated posteriorly. Dimensions: width 3½ inches; height 2 inches.

Geological position.—Zones of *A. capricornus*, Hummersea; *A.*

Jamesoni, Huntcliff, Robin Hood's Bay; *Am. margaritatus*, Huntcliff, Staithes, Hawsker; *Am. spinatus* (passim); *Am. annulatus* Hob Hill, Boosbeck.

Pleuromya rotundata, *Zieten.*

1830. *Amphidesma rotundatum.* 'Verst. Würt.' t. lxxii. f. 2, p. 95.

Geological position.—Zone of *Am. annulatus*, Skelton Park Pit.

Pleuromya bituminosa, *Spec. nov.*

Pl. XII., fig 9.

Transversely ovate elongate, with thick striated concentric ribs; anterior side very short, convex; posterior side produced, compressed and roundly truncated; front margin slightly convex; umbones rather large, incurved, approximate. Is less inflated in the umbonal region than *P. costata*, and has a shorter anterior side than it, and differs from its congeners in its truncated posterior margin. Dimensions: width $1\frac{3}{8}$ inches, height $\frac{5}{8}$ inch.

Geological position.—Zone of *Ammonites serpentinus*, Skelton Park Pit and Staithes (2 exs.).

Pleuromya granata, *Simpson.*

Pl. XIII., fig 7.

1855. *Venus granata.* Simpson. 'Foss. Y. L.' p. 121.

"Ovate, equivalve, inequilateral, transverse; anterior side short, rounded, obtuse; posterior elongated, depressed, rounded (or subtruncated), base convex; beaks (incurved, broad, inflated), approximate. Transverse striæ numerous, fine, unequal, dotted all over with small granules. Width 3 inches, height 2 inches, thickness $1\frac{1}{4}$ inch."

The shell varies from ovate to ovately oblong, and resembles *P. meridionalis*, Dumortier, but is not so much produced posteriorly.

Geological position.—Neither locality nor horizon is given by Simpson for this species; but we have obtained it from the *margaritatus*-beds at Staithes.

Pleuromya Dunkeri, *Terquem.*

1855. 'Pal. de Hettange,' p. 284, t. xviii. f. 13.

Geological position.—Zone of *Am. Bucklandi*, Marske Bay (1 ex.).

Pleuromya mundula, *Spec. nov.*

Pl. XII., fig. 11.

Shell ovately-elliptical, transverse, depressed, subequilateral; umbones small, depressed, submedial, transverse, contiguous; anterior side broad, margin arcuate; posterior side somewhat narrowed and produced, margin rounded; front margin curved. Surface wrinkled and striated concentrically. Lunule small, lanceolate; escutcheon narrow and deep. Dimensions: width $2\frac{3}{16}$ inches; height $1\frac{2}{10}$ inch; thickness $\frac{7}{10}$ inch; width of anterior side $\frac{9}{10}$ inch, posterior $\frac{14}{10}$ inch.

P. mundula has much the aspect of an *Arcomya*, and differs from all the Liassic species of the genus in its narrow, subequilateral form.

Geological position.—Zone of *Am. margaritatus*, Huntcliff, Staithes.

Pleuromya Crowcombeia, *Moore.*

Pl. XIII., fig. 10.

1861. *Pteromya.* 'Quart. Jour. Geol. Soc.' vol. xvii. t. xv. fs. 22, 23, p. 506.

Syn. 1861. *Myacites musculoides.* Auctores Anglicorum. Phillips. 'Thames Valley,' t. vii. f. 36 (non Schlotheim).

The so-called *Myacites musculoides*, so well known to collectors in the basal or White Lias beds of the Severn Valley, occurs in Yorkshire on the same horizon, constituting the main mass of its limestones. It is incorrectly referred to Schlotheim's species.

The shell is inequilateral, with pointed umbones of moderate size; the front is strongly arched and the posterior side is recurved superiorly and much attenuated, giving it the aspect of a *Ceromya;* not unfrequently an ill-defined keel proceeds from the umbo to the antero-posterior angle; the surface is usually strongly grooved concentrically, and the cast exhibits a few radial lines. Width 1 inch, height $\frac{6}{10}$ inch.

The Yorkshire shells are matched by one from the White Lias of Somersetshire, in the Bath Museum, named ***Pteromya Crowcombei*** by the author of the species, else I should not have assigned our specimens to it. Associated with these indubitable examples of *P. Crowcombei* are very large shells, seemingly adult forms of that species, but which have a strong resemblance to *Ceromya infra-liassica.* Peters (Lias von Fünfkirchen, t. i. fs. 1–3, 1863).

Geological position.—Zone of *Am. planorbis* (lower part), Slake's Pit, Coatham; Eston Gypsum Pit; Foxton and near Northallerton; about Thornton-le-Street (not *in situ*); Cliff.

Pleuromya æqualis, *Simpson.*

Pl. XIV., fig. 8.

1855. (*Amphidesma.*) 'Foss. Y. L.' p. 125.

"Subequilateral; posterior side the longer; transversely and obsoletely striated."—Simpson.

An incomplete specimen; the posterior extremity is gone and the anterior margin partially obliterated. The produced anterior side combined with its subinflated form distinguish it from other liassic species. Dimensions: height $1\frac{1}{4}$ inch, greatest thickness $\frac{5}{8}$ inch; estimated length $2\frac{1}{2}$ inches; length of anterior side $\frac{9}{10}$ inch.

Horizon and locality unknown, but because of the smooth shale, without mica adherent to the specimen, I venture to assign it to the Alum Shale. Specimen unique, Whitby Museum.

Pleuromya contracta, *Simpson.*

Pl. XVI., fig 9.

1855. (*Amphidesma.*) *Op. cit.* p. 124.

"Equivalve; for half the width subcylindrical; anterior side very short, obtuse; posterior angular; width more than twice the length."—Simpson.

The unique type is a rubbed cast with the posterior end slightly worn, the surface shows a few concentric folds. Width 1·5 inch; length ·7 inch; thickness ·7 inch.

"Upper Lias, Whitby." Simpson (Whitby Museum).

Pleuromya ? elegans, *Phillips.*

1829. *Sanguinolaria.* 'Geol. York.' t. xii. f. 9.

I have not seen any examples of this species. It is recorded from calcareous nodules in the Upper Lias and from the Lower Lias. The type seems to belong to the Upper Lias and to have some affinity with *P. Crowcombeia.*

Ceromya gibbosa, *Etheridge.*

1863. 'Quart. Jour. Geol. Soc.' vol. xx. p. 112, fs. 3, 4.
Syn. 1850. *Isocardia Elea.* D'Orbigny. 'Prod.' vol. i. p. 218.

The specific identity of *C. gibbosa* and *I. Elea* results from a comparison of the two types, but the diagnosis of the latter is insufficient to establish the species.

Geological position.—Zone of *Am. angulatus*, Redcar (2 exs.).

Ceromya petricosa, *Simpson.*

Pl. XIV., fig. 1*a*, *b*.

1855. *Venus petricosa.* Simpson. 'Foss. Y. L.' p. 121.
Syn. 1867. *Isocardia liassica.* Moore. 'Up. and Mid. Lias,' p. 101, t. vii. f. 3.

"Subtriangular, ventricose, inequilateral, transverse; anterior side short, obtuse, rounded; posterior side subangular, depressed. rounded; base convex; beaks reincurved, approximate; transverse striæ numerous, fine, unequal (dotted all over with small granules). Width, 1¾ inch." Simpson. The shell is smooth and shining, but I fail to recognise the granulations attributed to it by Simpson. Having seen the types, I confidently assert that *Isocardia liassica* and *Venus petricosa* are identical.

Geological position.—Zones of *Am. margaritatus* (upper beds), Staithes (not rare), Hawsker; *Am. spinatus*, Hutton, near Guisborough (1 ex.), Staithes.

Ceromya bombax, *Quenstedt, sp.*

1858. (*Venus.*) 'Jura,' t. xxiii. f. 21, p. 189.
1871. (*Isocardia.*) Brauns. 'Unt. Jura,' t. ii. fs. 5-7, p. 329.

Young shells of this species are ovately-orbicular, moderately convex and nearly equilateral; in one example the posterior side is the shorter. I have a few specimens agreeing in size and shape with Brauns's figure, the hinge characters of which are those belonging to *Ceromya;* it is the most equivalve of the genus.

Geological position.—Zone of *Am. spinatus*, Eston, Upleatham, and Hob Hill Mines.

Ceromya sublævis, *Spec. nov.*

Pl. XII., fig. 6.

Shell subtrigonal, ventricose, thin; slightly inequilateral; umbones inflated, depressed and involute, nearly central; anterior side rounded, posterior side truncated, attenuated; front margin much curved; lunule broad, shallow; surface with fine and closely arranged ridges of growth; acute anteriorly; depressed on the posterior side. Breadth 3¾ inches; height 3 inches; thickness nearly 2 inches. Mr. Lee has one specimen measuring 3½ by 4 inches.

This species resembles *C. gibbosa*, but has a more circular outline more gracefully rounded anteriorly, and the posterior side not so produced but abruptly truncated; the umbones are more inflated and elevated. Its systematic position is placed beyond doubt through the characters afforded by the interior of a *left* valve, especially that of an erect lamina confluent with the

hinge behind the umbo, beneath which it originates, gradually increasing in breadth, and abruptly truncated behind.

Geological position.—Zone of *Am. spinatus*, Hob Hill, Upleatham, Eston, and Belman Mines (8 exs.).

Ceromya exarata, *Tate.*

Pl. XIII., fig. 6.

Syn. 1828. *Cardita nitida.* Young and Bird. 'Geol. Sur.' p. 227, t. viii. f. 22.
1855. *Isocardia nitida.* Simpson. 'Foss. Y. L.' p. 119.

Shell subglobose, nearly equilateral; umbones prominent, involute, contiguous; posterior side subtruncated, the slope divided into two areas by a shallow sulcus, beyond which the shell is depressed, as if it were attenuated in this part. Surface raised into closely-set rounded ridges of growth, with narrower interspaces. Size not exceeding half-an-inch in height and width.

All the known specimens of this species are casts, they are found in the limestone doggers, and present a smooth, shining exterior. Young and Bird considered this species as related to *Cardita similis*, Sow., but smaller and concentrically ribbed; their figure, quite unintelligible without a specimen of the shell before you, represents an end view. Though better placed by Simpson in the genus *Isocardia*, and sufficiently described by him, yet it is advisable to apply a new name, as *Isocardia nitida*, Phillips, is a well-established species, differing from the present species but congeneric.

Geological position.—Zone of *Am. serpentinus*, Kettleness; Whitby (Whitby Museum).

Thracia Grotiani, *Brauns.*

1871. 'Die Untere Jura,' t. ii. fs. 3, 4, p. 314.

The identification is not the most satisfactory; the differences may, however, be due to age.

Geological position.—Zones of *Ammonites capricornus*, Huntcliff; *A. margaritatus*, Staithes, and *A. spinatus*, Eston Mines (an ex. from each zone).

Thracia glabra, *Agassiz.*

1843. (*Corimya.*) 'Etudes, &c. Myes,' p. 265, t. xxxviii. fs. 5–15.

Geological position.—Zone of *Ammonites communis*, Boulby and Slapewath Alum Works (3 exs. no locality, Whitby Museum).

Genus Arcomya, *Agassiz.*

These are *Pleuromyæ* with an *Anatina*-like form, and recurved umbones; earlier authors named them *Sanguinolaria*.

Arcomya vetusta, *Phillips.*

1829. (*Sanguinolaria.*) 'Geol. York.' p. 14, f. i.
1855. (*Sanguinolaria.*) Simpson. 'Foss. Y. L.' p. 130.

Shell trapezoidal, transverse; anterior side short, margin rounded; posterior side compressed and enlarged, margin obliquely truncated; an obtuse keel proceeds from behind the umbo to the posterior angle; front margin straight; umbones depressed, incurved, approximate, anterior surface raised into depressed plications, and finely striated; the plications are prominent on the umbonal region. Breadth, 3 inches; height, $1\frac{1}{2}$ inch; thickness, $\frac{8}{10}$ inch.

Geological position.—The species is almost confined to the zone of *Am. armatus*, at Robin Hood's Bay, Kirby Underdale, and Warter, whence we have obtained a few examples agreeing in all particulars with Phillips's figure; but a few small shells from the uppermost part of the *oxynotus*-beds, Robin Hood's Bay, are, doubtless, young examples of this species.

In addition to the locality of the type-specimen "Lower shale," Robin Hood's Bay, Phillips records his species from the "Marlstone Roseberry," but it is probable that *Arcomya arcacea* was thence obtained.

Arcomya elongata, *Römer.*

1836. *Panopæa elongata.* Römer. 'Ool. Geb.' t. viii. f. i. p. 126.
Syn. 1845. *Sanguinolaria striata.* Buckman. 'Geol. Cheltenham,' t. x. f. 10.
1850. *Panopæa Pelea.* D'Orbigny. 'Prod. I.' p. 233.

This is an elongated shell, not likely to be confounded with the last, and is not known beyond the confines of the united zones of *A. Jamesoni* and *A. Ibex* in England, France, and Germany.

Geological position.—Zone of *Am. Jamesoni*, Huntcliff, Coatham, Normanby, Easby, Robin Hood's Bay.

Arcomya arcacea, *Seebach.*

1864. (*Pleuromya.*) 'Hannov. Jura,' t. v. f. iv. p. 128, id.
1871. (*Pleuromya.*) Brauns. 'Unt. Jura,' p. 307.

Geological position.—Zones of *A. margaritatus*, Staithes, Huntcliff; *Am. spinatus*, Kettleness, Hawsker.

Arcomya longa, *Buvignier.*

Pl. XI., fig. 11.

1853. (*Panopæa.*) 'Géol. Meuse,' t. vii. fs. 1–3, p. 6.
Syn. 1853. *Panopæa Broliensis.* Buvignier, id. t. viii. fs. 6, 7, p. 6.

Moderate-sized specimens of the large *Arcomya* in the Cleve-

land ironstone agree in shape and ornament with *P. longa*, Buv., and the description accords. A character possessed by our shell is not given by Buvignier—it is that of a broad, just perceptible depression in the axis of the umbo. An example with a shorter anterior side agrees with *P. Broliensis*, but it is not separable from *A. longa*.

Geological position.—Zone of *Am. spinatus*, only in the oolitic portion of the ironstone, Eston, Upleatham, Hob Hill, and mines near Guisborough, Hotham, Dalton Road, Market Weighton. Buvignier's types are from the Calcaire sableux supérieur du Lias at Breux.

Arcomya concinna, *Spec. nov.*

Pl. XI., fig. 1.

Shell transverse, oblong, elongate, inequilateral, depressed; umbones small, prominent, incurved, contiguous, anterior hinge straight; anterior side slightly concave, produced, the margin semicircular; posterior side produced, attenuated; front margin nearly straight. Surface with slender concentric plications and striæ, densely granulated. Breadth, 2½ inches; height, 1¼ inch; thickness, ¾ inch.

Compared with *A. arcacea*, this species presents the following differences: depressed, not so ventricose in the umbonal region, tapering behind, and without a posterior keel. The smallest example of *A. longa* is half-an-inch broader than the largest specimen of *A. concinna*, and presents all the distinctive characters of the species, so strikingly different from those of *A. concinna*, that I cannot yet admit that the one is the adult of the other.

Geological position.—Zone of *Ammonites spinatus*, Eston, Upleatham, and Hob Hill Mines (not uncommon).

Arcomya hispida, *Simpson.*

Pl. XIV., fig. 3.

1855. (*Mya.*) 'Foss. Y. L.' p. 126.

"Very inequilateral, very transverse; posterior side much produced, slightly curved upwards; upper and lower sides nearly parallel, transversely striated, and covered with fine points; width nearly four [three] times the length. This is so transverse that it has a good deal the appearance of a blade of a knife; rather tumid about the beaks."

This proves, on removal of the matrix, to be a fragment of the hinge-line of an inequilateral *Arcomya*, of greater width than originally described, and presenting characters which separate it from the other Yorkshire species of the genus.

Geological position.—Zone of *Am. margaritatus* (Whitby Mus.).

Saxicava arenicola, *Terquem.*

1855. 'Pal. de Hettange,' t. xviii. f. 7, p. 287.

Geological position.—Zone of *Am. angulatus*, Cliff (2 exs.).

This, or a related species, has occurred in the *armatus*-beds at Warter.

CLASS PALLIOBRANCHIATA.

BY RALPH TATE.

The Palliobranch or Brachiopod shells of the Yorkshire Lias have received from a very early date a considerable share of attention, from the circumstance, no doubt, of their relative abundance. Sowerby in 1826 named his *Discina reflexa* from Yorkshire examples. Young and Bird in 1828 figured and gave short notices of several species, of which we may venture to particularise, *Discina reflexa*, *Terebratula punctata*, *Rhynchonella tetrahedra*, *R. lineata*, and *R. calcicosta*. Phillips (1829) added to the list *Spiriferina Walcotti*, *Rhynchonella acuta*, and *Terebratula resupinata*; and Oppel (1856), *Lingula Longovicensis*, and *Spiriferina Tessoni*; and finally Simpson, who records several of the above under different names, describes as new species *Waldheimia Sarthacensis*, D'Orb., and *Rhynchonella plicatissima*, Quenst. Thus, eliminating all synonyms, our predecessors have handed down to us 12 well-established species; to this number we add 12, including some rare forms and two new species.

It is with the greatest pleasure that I acknowledge the valuable aid rendered to me in this department of Palæontology by Thomas Davidson, Esq., F.R.S., whose truthful delineations of Yorkshire liassic Brachiopoda on plate 15 presented to us, demand attention. His critical remarks upon the specimens submitted to him have been fully appreciated, and we are in the main agreed upon the validity of the species which are described in the following pages.

Lingula longovicensis, *Terquem*.

Pl. XV., figs. 1 to 4.

1850. 'Bulletin Soc. Géol. de France,' vol. viii. 2nd ser. p. 12.
1854. Chapuis and Dewalque. 'Pal. de Luxembourg,' p. 234, t. xxxv. f. 5.
1856. Oppel. 'Die Juraformation,' p. 266.
Syn. 1855. *Lingula venusta*. Simpson. 'Foss. York. Lias,' p. 130.

This small species is separable from *L. Beani* by its ovate lanceolate form; fig. 3 represents the largest specimen that we have collected, it measures $\frac{7}{20}$ inch in length, and $\frac{4}{20}$ inch in breadth; it is a mould of the interior of the dorsal valve exhibiting casts of the elongated impressions of the adjustor muscles.

Specimens of *L. venusta*, Simpson, in the Whitby Museum, are characteristic examples of the species.

The test is very membranaceous, extremely thin, and externally of whitish-blue colour.

The species was first recorded as British by Simpson, under the above-quoted name, from examples obtained at Whitby. Oppel quotes it from the same locality under the name that is here adopted.

Geological position.—Zone of *A. communis*, Whitby, 30 feet below the *striatulus*-beds (Simpson); Alum Shale, Whitby (Oppel); Alum Shale, East Arncliffe, Glaizedale (3 exs.); Sigston Wood 3½ miles west of Northallerton (1 ex.); Skelton Park, and Long Acres Pit Sinkings, near to the base of the Alum Shale (common).

Lingula sacculus, *Chapuis and Dewalque.*

1854. 'Foss. de Luxembourg,' t. xxxv. f. 4, p. 233.
Syn. 1863. *L. Voltzii.* Deslongchamps. 'Bull. Soc. Linn. de Normandie,' vol. vii. t. iv. fs. 7–8.
1869. Dumortier. 'Dép. Jurass.' vol. iii. t. xxiv. fs. 1–2.

The specimens of Lingulæ obtained from the Middle Lias in Yorkshire, and which seem to agree with the figures of *L. sacculus* of Chapuis and Dewalque, have some resemblance with *L. Beanii*, from which they differ in being more pointed apically, whilst that species has a more truncated shell; so that *L. sacculus* has a subovate outline, whilst that of *L. Beanii* is ovate oblong. The test of *L. Beanii* is remarkably thick and of a light-blue colour, that of *L. sacculus* is thin and of a black-blue.

This species has usually been quoted as *L. Voltzii*, Terquem ('Bull. Soc. Géol. de France,' vol. viii. t. i. f. 2, 1850), the description and figures of which do not admit a doubt as to its identity with *L. Beanii*. *L. Voltzii* of Deslongchamps, and of Dumortier, apparently belongs to *L. sacculus*. An occasional specimen of one or other species may be found of an intermediate form, but I cannot accept an aberrant example or so as proof of identity of *L. Beanii* and *L. sacculus*, when so very many specimens of each have been observed to exhibit a common character each to each.

L. Beanii is known to me only as an Inferior Oolite fossil in Yorkshire, and there is no proof of a greater antiquity for it.

Geological position.—Zone of *Ammonites spinatus*, Kettleness (1 ex.); Upleatham (3 exs.); *A. armatus*, Staple Hole Quarry, Langbargh (4 exs., dwarfed).

Discina reflexa, *Sowerby.*

Pl. XV., figs. 5, 6.

1826. (*Orbicula.*) 'Min. Con.' t. dvi. f. 1, p. 134.
Syn. 1816. *Patella lævis.* Sowerby. 'Min. Con.' t. cxxxix. f. 3 (non 4).
1828. *Patella lævis.* Young and Bird. 'Geol. Sur.' p. 249, t. xi. f. 10.
1861. *Discina orbicularis.* Moore. 'Geologist,' vol. i. t. ii. fs. 16–18.

The type of this species is from the sandy beds surmounting

the Upper Lias cement beds at Blea Wyke, which we class with the Inferior Oolite. However, *D. reflexa* seems to have made its first appearance in the Alum Shale, but the examples from this horizon are smaller than those from the Inferior Oolite.

The upper shell has been figured, and the under side of the attached valve has been described, but the interior of the latter has hitherto been unknown, it is represented on fig. 6*a*. The small oval foramen for the plug is placed in the middle of the prominent rather small muscular disk, from which radiate upon the smooth surface a few striæ.

An immature example of this species from the Alum Shale of Whitby is figured by Sowerby under the name of *Patella lævis*, which Oppel, 'Die Juraf.,' p. 267 wrongly refers to *Lingula Longovicensis*; *D. Davidsoni*, Moore represents the species in a similar condition.

The majority of the specimens from the Upper Lias are more or less flattened by pressure, in which state they agree in form with *D. papyracea*, Münster, and to which species Oppel referred specimens from the Alum shale of Whitby. My opinion, from a careful examination of many specimens in different states of preservation and of different sizes, is that all the above references belong to *D. reflexa*.

Oppel considered *D. papyracea* as distinct from *D. reflexa*, and referred to it the specimens mentioned by Sowerby as coming from the Alum shale of Whitby, and thus sought to limit *D. reflexa* to the Inferior Oolite.

D. reflexa as a Yorkshire Lias fossil has been recorded by Phillips and Simpson. It is very commonly parasitic on *Ammonites cornucopia* which is most abundant in the zone of *A. serpentinus*, but we have not found such a specimen *in situ*. This has been noticed also by Dumortier in the Lias of the south of France, and he has hence called the species *D. cornucopia*.

Geological position.—Zone of *A. communis*, Whitby; Lofthouse Alum Works; Pit sinkings, Skelton; Carlton Moor Alum Works, Stokesley. *A. Jurensis*, Peak.

Discina Holdeni, *Tate*.

1867. 'Quart. Jour. Geol. Soc.' vol. xiii. p. 314.
Syn. 1865. *Discina sp.* Terquem and Piette. 'Lias Inf. de l'Est de France,' t. xiv. fs. 33-34, p. 113.
1871. *Orbicula angulata.* Quenstedt. 'Die Brachiopoden,' t. lx. f. 113.

I refer to the above species, which is distinguished from *D. reflexa* by its central apex and well-marked concentric ridges, three immature shells obtained by Dr. Wilson from the *Bucklandi*-beds at Marske, and by myself from a well-sinking at Redcar, in the lower part of the series.

Thecidea belemnitica, *Spec. nov.*

Pl. IV., fig. 5.

The internal surface of the attached valve of a species, probably of this genus, is exhibited on two specimens of *Belemnites charmouthensis*. It has the shape of a *Thecidea*, being longer than broad; hinge-line nearly straight, enlarged and rounded in front; no area visible. The arrangements of the hinge and muscles more nearly resemble those of a *Leptæna*, under which genus it is recorded in Part I. There are two sharp teeth not far from the median line, and from them, as bases, expand two oval muscular impressions, each divided by a median line, and reaching about half-way across the shell. Dimensions: length, 4½ lines; breath, 3½ lines.

Geological position.—Zone of *A. Jamesoni*. Robin Hood's Bay (2 exs.).

Spiriferina Walcotti, *Sowerby.*

Pl. XV., fig. 9.

1823. (*Spirifer.*) 'Min. Con.' t. ccclxxvii, fs. 1, 2.
1851. (*Spirifer.*) Davidson. 'Brit. Foss. Brach.' t. iii. fs. 2, 3.

I have examined typical examples of this species from the following localities:—

Zone of *Am. Bucklandi*. Redcar and Marske (not rare), "Lower Lias, Robin Hood's Bay, Whitby" (*Simpson*, Whitby Mus.). *Am. spinatus*. Eston (1 ex.) and Belman Mines, near Guisborough (1 ex.).

Var. lata.

Syn. 1855. *Liasicus, recentior*. Simpson. 'Foss. Y. L.' p. 133.
1860. (*Spiriferina.*) Martin. 'Infralias de la Côte-d'Or,' t. vii. fs. 1-4.

This variety approaches *S. Münsteri*, Davidson. It is usually wider than long; the mesial fold in the smaller valve rounded, and but slightly elevated, with 4 to 6 subacute plaits on each side. The beak projected backwards and straight, producing a large triangular area.

Geological position.—Zones of *Am. Bucklandi*, Marske (1 ex.); *A. armatus*, Robin Hood's Bay (common).

Spiriferina rostrata, *Schlotheim.*

1822. (*Terebratulites.*) 'Nachtrag z. Petref.' t. xvi. f. 4.
1851. *Spirifer rostratus*. Davidson. 'Brit. Foss. Brach. (Pal. Soc.),' t. ii.

Geological position.—A single example of a pedunculated valve from the *angulatus*-beds at Redcar is referred to this species, and

a small example in the alveoles of a Belemnite in the *margaritatus*-beds. Hawsker.

Spiriferina oxyptera, *Buvignier.*

Pl. XV., fig. 8.

1843. *Spirifer.* 'Mém. de la Soc. Philom. de Verdun,' vol. ii. p. 14, t. viii. f. 8.
1852. Davidson, 'Ann. and Mag. Nat. Hist.' p. 16, t. xv. fs. 5–7.

Geological position.—Zone of *Am. Jamesoni.* Huntcliff, Saltburn, and Coatham Scars, Redcar (22 exs.).

This species occurs at the same horizon in Mull, and Raasay, W. Hebrides.

Spiriferina Signiensis, *Buvignier ?*

Pl. XV., fig. 7.

1843. (*Spirifer.*) *Loc. cit.* p. 14, t. v. f. 9.
1852. (*Spirifer.*) Davidson. 'Annals and Mag. Nat. Hist.' p. xvi. t. xv. f. 3.

The validity of this identification is questionable; but I have less hesitation in assigning the shell to *S. Signiensis* than to any other species of the genus.

Geological position.—Zone of *Am. spinatus*, in the shale below the main seam of ironstone, Eston (one valve only).

Spiriferina Tessoni, *Davidson.*

1852. 'Ann. and Mag. of Nat. Hist.' t. xv. fs. 1–2.
1856. Oppel. 'Die Juraformation,' p. 186.

This magnificent species is introduced here on the authority of Oppel, who records it from the zone of *Am. margaritatus*, Robin Hood's Bay, in the following terms:—"Fand ich in dem Marlstone von Robin Hood's Bay (Yorkshire) einen Spirifer, der mit *Spir. Tessoni* ganz übereinstimmt."

Terebratula punctata, *Sowerby.*

1812. 'Min. Con.' t. xv. f. 4, p. 46.
1851. Davidson. 'Brit. Foss. Brachiopoda,' t. vi. fs 1–6, p. 45.

Our examples agree with the types of this species in form, but do not attain to so large a size. They exhibit characters intermediate between *Terebratula* and *Waldheimia.* The crural processes extend far towards the front of the shell; the septum, though short, is very prominent, and the beak-ridges are distinct. Considerable variation in the shape and size of the

foramen is presented by the large series obtained from the Yorkshire Lias; in many, and especially those from the ironstone, it is compressed and narrow: in others large and broad, approaching to circular, and in this respect resembles *T. subpunctata.*

This species is possibly the one referred to by Young and Bird, *loc. cit.*, p. 231, as related to their *T. trilineata*, and belonging to the ironstone-bands; and by Simpson, *loc. cit.*, p. 130, under the name of *T. ornithocephala*, and is evidently Hunton's *T. trilineata*, catalogued as very abundant in the ironstone-bands at Rockcliff. It was first identified by Phillips in 1829.

Geological position.—Zone of *Am. margaritatus.* Huntcliff, Staithes, Grosmont (rare and small).

Zone of *Am. spinatus.* Eston, Upleatham and other Mines, Staithes, Grosmont, Bransdale, &c. (common, and widely distributed).

Waldheimia sarthacensis, *D'Orbigny.*

Pl. XV., figs. 10, 11.

1850. D'Orbigny. 'Prodromus,' p. 270.
Syn. 1815. *Terebratula ornithocephala.* Sowerby (pars). 'Min. Con.' t. ci. f. 4.
1851. *Terebratula obovata.* Davidson. 'Brit. Foss. Brach.' t. v. f. 16.
1855. *Terebratula hispidula.* Simpson. 'Foss. Y. L.' p. 132.
1856. *Terebratula perforata.* Piette. 'Bull. Soc. Geol. France,' 2nd edit. vol. xiii. t. x. f. 1.
1856. *Terebratula psilonoti.* Quenstedt. 'Jura,' t. ix. f. 21.
1860. *Terebratula strangulata.* Martin. 'Pal. de la Côte-d'Or,' t. vii. fs. 8–10.

Whatever name the species should receive, there is no doubt that it has long been known in this country, having been confounded with *T. ornithocephala* by Sowerby as early as 1815, and by Portlock in 1843, and in later times more frequently with *T. punctata.*

We have figured two examples obtained from widely-separated horizons: that from the *angulatus*-beds, Pl. XV., fig. 10, is the one more commonly known as *T. perforata*, Piette, and the other, Pl. XV., fig. 11, from the *armatus*-series, is identical with *T. hispidula*, Simpson, and with *T. Sarthacensis*, Deslongchamps.

The shell is distinguished by its subpentagonal form and small umbo, and is closely allied to *W. indentata*, Sow., but does not present an indented front, from which character the latter species owes its name.

Sowerby's *T. ornithocephala*, t. CI., fig. 5, comes from the "blue marls of the lias of Pickeridge Hill," south-east of Taunton; and from the same locality were obtained the types of *Lima pectinoides* and *L. punctata*, which circumstance places beyond dispute the liassic age of the *Terebratula.* Davidson has figured this specimen as the type of Sowerby's *T. obovata*, the original of which is overlooked by him.

Agassiz, in his translation of Sowerby's 'Mineral Conchology,' 1845, thinks that it should have been made a distinct species, which was done by D'Orbigny in 1850, who called it *T. Sarthacensis*.

It would appear that D'Orbigny referred to this species examples of a Terebratula from the Middle Lias, one of which is taken by Deslongchamps, 'Pal. Fr.,' t. XXXI., fig. 6, as representing D'Orbigny's species, which Brauns regards as synonymic with *T. indentata*, Sow. Deslongchamps' figure most accurately represents our shell from the lower part of the Middle Lias; but the type of *T. Sarthacensis* is obviously *T. ornithocephala*, Sow., t. CI., fig. 5, and this name the species should receive, taking priority of *T. hispidula* and *T. perforata*.

Geological position.—Zones of *Am. angulatus*, Market Weighton (2 exs.), Redcar (5 exs.); *Am. armatus*, Robin Hood's Bay (20 exs.); *Am. Jamesoni*, Huntcliff, Coatham, Normanby, Upsall, Easby; *Am. spinatus*, Grosmont.

Waldheimia Lycetti, *Davidson*.

1851. 'Brit. Foss. Brach.' t. vii. fs. 17-22.

Geological position.—Zone of *Am. Jurensis*. Peak (1 ex.).

Waldheimia resupinata, *Sowerby*.

Pl. XV. figs. 12, 13.

1816. 'Min. Con.' t. cl. fs. 3, 4.
1829. Phillips. 'Geol. York.' t. xiii. f. 28.
1851. Davidson. 'Brit. Foss. Brach.' t. iv. fs. 1-5.

The Yorkshire examples which I refer to this species all differ from the typical form. They may be grouped under two varieties.

Var. a (Pl. XV., fig. 13) is the commonest shell in the Cleveland main seam, to which it is confined. This form differs from the type in being more elongated and narrower, the medial sulcus deeper, and the sides consequently more elevated; it shows a great approach to *W. carinata* of the Inferior Oolite.

Var. b (pyriformis, Pl. XV., fig. 12) has occurred to me only in the shelly shale (or "cockle-bed") below the main seam at Eston. This variety exhibits a much greater departure from the usual examples of this species in its ovate shape, gibbous valves, and the shallow or ill-defined sulcus on the brachial valve, but agrees with the large specimens of the species figured by Davidson.

Geological position.—Zone of *Am. spinatus*. Wilton (*Phillips*), Eston, Upleatham, Hobb Hill, Skinningrove, Belman.

Genus Rhynchonella.

This group of shells presents unusual difficulties to the

student who does not hold the opinion that distinction of species is a mere abstraction; the variation of form presented by the Yorkshire examples of the genus is so excessive as to make it comparatively easy to connect together all the so-called species. Nevertheless, by selecting groups obtained from different geological horizons, sufficient differences are noticeable between them, which, for practical purposes, may be regarded as of specific value.

Rhynchonella acuta, *Sowerby.*

1818. (*Terebratula.*) 'Min. Con.' t. cli. fs. 1, 2, p. 115.
1829. (*Terebratula.*) Phillips. 'Geol. York.' t. xiii. f. 25.
1867. (*Rhynchonella.*) Davidson. 'Brit. Foss. Brach.' t. xiv. fs. 8, 9.

Geological position.—Zone of *Am. margaritatus* (bottom seam of ironstone). Hutton, Guisborough, one specimen. Recorded by Phillips from Wilton and Bilsdale, and by Hunton from Rockcliff.

Rhynchonella furcillata, *Von Buch, sp.*

1834. 'Ueber Terebratulen.'
1851. Davidson. 'Brit. Foss. Brach.' t. xiv. fs. 2-5.

Geological position.—Zone of *Am. Jamesoni*, Huntcliff (3 exs.); *A. armatus*, Kirby Underdale (1 ex.).

Rhynchonella subconcinna, *Davidson.*

Pl. XV., fig. 18.

1851. Davidson. 'Brit. Foss. Brach.' t. xvii. f. 17, p. 90.

Geological position.—Zones of *Am. Jamesoni*, Huntcliff, Peak (4 exs.); *A. capricornus*, Huntcliff (a doubtful example); *A. spinatus*, Eston (a doubtful example).

Rhynchonella rimosa, *Von Buch.*

1831. (*Terebratula.*) 'Pétrefactions Remarquables,' pl. vii. fig. 5.
1851. (*Rhynchonella.*) Davidson. 'Brit. Foss. Brach.' t. xiv. fs. 6, 6*a*.

Geological position.—Zone of *Ammonites Jamesoni.* Huntcliff and Coatham Scars (4 exs.).

Rhynchonella tetrahedra, *Sowerby.*

Pl. XV., fig. 20.

1822. (*Terebratula.*) 'Min. Con.' t. lxxxiii. f. 5.
1828. (*Terebratula.*) Young and Bird. 'Geol. Sur.' t. viii. f. 15.
1851. (*Rhynchonella.*) Davidson. 'Brit. Foss. Brach.' t. xviii. fs. 5-10.
1855. (*Terebratula.*) Simpson. 'Foss. Y. L.' p. 130.
Syn. 1855. *Terebratula compressa.* Simpson, *loc. cit.* p. 130.

This very characteristic fossil of the Middle Lias is too well

known to need description at my hands; however, for the purpose of comparison it is necessary that the characters presented by the young shells be indicated in this place. Quenstedt has figured a series of medium-sized and young examples of *R. tetrahedra*, under the name of *Terebratula amalthei*, 'Die Brachiopoden,' t. XXVII. fs. 154 to 160. The beak in the young forms is suberect, not incurved as in the adult; the shape is depressed and subtriangular, and in the youngest examples traces of the plaits are discernible. Simpson says his *R. compressa* is "probably another variety of *R. tetrahedra*;" I have not seen the specimen upon which the species is founded.

Geological position.—Zones of *Am. armatus*, Robin Hood's Bay; *Am. Jamesoni*, Huntcliff, Coatham, Peak; *Am. margaritatus*. Danby Dall, Carlton Moor, Huntcliff; *Am. spinatus*, Cleveland main seam where it is abundant. Eston, Upleatham, &c.; Staithes, Grosmont, Millington.

The four following species have usually been referred to the problematical *R. variabilis*, which seems to have been a refuge for the uncertain forms obtained in the Lias. In the examination of these and other species it is inconvenient to insist upon sharp lines of demarcation, and the validity of the species may perhaps be called into question, yet I greatly rely upon the distinctions that have been drawn from the characters afforded by the young shells.

Rhynchonella lineata, *Young and Bird, sp.*

Pl. XV., figs. 21, 22, and 23.

1828. (*Terebratula.*) 'Geol. Sur.' p. 232, t. viii. f. 10.
Syn. 1829. *T. triplicata* and *T. bidens*. Phillips. 'Geol. York.' t. xiii. fs. 22–24.
1855. *T. triplicata*. Simpson. 'Foss. Y. L.' p. 131.
1851. *T. triplicata, variabilis*. Davidson. 'Brit. Foss. Brach.' t. xvi. fs. 1–6.

Adult forms of this species have a resemblance to *R. tetrahedra*, but differ in the number and character of the plaits, and in the larger, less incurved beak and large foramen. There are invariably 2 or 3 plaits on the mesial fold, with from 3 to 4 on each lateral area of the brachial valve, which are all evanescent towards the umbo.

Phillips distinguished two forms, that with three plaits as *triplicata*, and that having two on the mesial fold as *bidens*; our figures 21 and 22 represent these two variations. Young and Bird's description and figure belong to the *bidens*-form; and as there can be no doubt respecting the shell figured by them, supplemented by a sufficiently full description, I adopt their name in accordance with the rule of priority. The description reads as follows: "No. 10 is a small shell, very common in the

ironstone bands and in the Dogger; it differs from *T. tetrahedra*, not only in being smaller, but in having only two elevated plaits at the base, and a sunk line on the lesser valve, running from the beak to a groove between these plaits. There are about 4 plaits on each side of the beak, besides those of the base." As regards size, however, it not unfrequently equals the largest specimens of *R. tetrahedra.*

Fig. 23 represents a cast of the umbonal region of the dorsal valve of *R. lineata*, in which are shown the denticulated sockets, a character which also belongs to *R. rimosa* and *R. acuta*: vide Quenstedt's 'Die Brachiopoden,' t. XXVII., f. 107 and f. 151.

The young shells are depressed, broadly subtriangular; the front edge of the united valves is at first straight, but gradually becomes arched as the shell is enlarged; no trace of plication is presented by specimens up to half-an-inch in breadth. The beak is erect and the foramen large.

There is no other alternative between regarding these small shells as the young of the *R. lineata* and assigning them to a new species, as they are found in company with *R. lineata* in the shales below the main ironstone seam, the only species of the genus occurring therein. The smallest specimen showing plications is ⅝ inch broad, but still retains the depressed shape of the juvenile examples.

Examples of *R. tetrahedra* at this stage have already been described, whilst young specimens of *R. acuta*, with a diameter ⅜ inch, present a strong mesial fold and lateral plications. I cannot agree with Simpson, who considers the species related to *R. tetrahedra* rather than *R. variabilis*, and still less with Brauns, who places it with *R. cynocephala* under *R. acuta*.

Geological position.—Zone of *Am. spinatus*. Very abundant in the shaly ironstone called the "Cockle Band" at the base of the Cleveland Main Seam, at Eston; also in the Main Seam Eston, Upleatham, Staithes, Runswick, Hawsker, &c.

Rhynchonella variabilis, *Schlotheim.*

1813. Leonhard. 'Min. Taschenbuch,' pl. i. fig. 4.
1852. *T. oxynoti.* Quenstedt. 'Handbuch,' t. xxxvi. fs. 4, 5.

The shells which I identify with Quenstedt's figures of *R. oxynoti* are more or less subglobose, with 2 or 3 plaits on the mesial fold, and about 3 plaits on each side; the plaits are usually confined to the front, though they occasionally reach to the umbo; the beak is very small, incurved, the foramen small and in the young shells subterminal. Specimens less than ⅜ inch broad show a biplicated mesial fold and distinct lateral plaits, excessively small beak closely applied to the dorsal valve, with a circular and terminal foramen, characters which are not possessed by *R. lineata* or *R. tetrahedra* at

the same stages of growth. The adult stages of *R. lineata* and some shapes of *R. variabilis* are almost undistinguishable.

Brauns identifies Quenstedt's species with Schlotheim's, and it is therefore here inscribed under the older name.

Geological position.—Zones of *A. armatus*, Robin Hood's Bay and Warter: *Am. Jamesoni*, Rockcliff, Huntcliff, Coatham, Robin Hood's Bay, Normanby, Upsall, Peak; *A. capricornus*, Huntcliff.

Rhynchonella plicatissima, *Quenstedt.*

Pl. XV., figs. 14, 19.

1852. (*Terebratula.*) 'Handbuch der Pet.' t. xxxvi. f. 3.
Syn. 1855. *T. mundula.* Simpson. 'Foss. Y. L.' p. 131.

This is a small-sized shell, subdepressed, with a moderately elevated mesial fold; surface strongly plaited at all stages of growth, plaits varying from 14 to 20; 4 to 5 usually, rarely 3 to 6 occupying the elevated part of the dorsal valve. Beak small, acute, incurved, often concealing the foramen, or suberect; foramen moderately large. Dimensions of largest specimen: breadth $\frac{8}{10}$ inch, height $\frac{2}{10}$ inch, thickness $\frac{7}{20}$ inch.

Having examined many a score of examples I have no hesitation in regarding the type form distinct from *R. oxynoti*, though some passages are possible; *R. plicatissima* exhibits little variation, it approaches to the subglobular form and the plaits may be partially or entirely obsolete. A few examples of the immature state of this species, called *R. gryphitica* by Quenstedt, have occurred in the *Bucklandi*-beds. Fig. 19 represents a form not rare in the oyster bands of the *capricornus*-series, which may be an aged example of this species; it agrees very well with *R. rimata*, Oppel, 'Deutsch. Geol. Ges.,' t. XII. f. 2, p. 542, 1861; other examples accord with *R. polyptycha* of the same author, t. XII. f. 4, and have considerable analogy with *R. serrata*, Sow.

Geological position.—Zones of *Am. angulatus*, Redcar (rare); Millington (rare); *Am. Bucklandi*, Redcar (not common); *A. raricostatus* and *A. armatus*, Robin Hood's Bay; *A. Jamesoni*, Upsall (sinking); Wood End, Ayton; *A. capricornus*, Huntcliff.

Rhynchonella calcicosta, *Quenstedt.*

Pl. XV. fig. 15.

1852. *Terebratula.* 'Handbuch,' t. xxxvi. fs. 6–9.

This species has much affinity with *R. plicatissima*, though it presents a decidedly different form. The majority of the specimens are triangular obovate, with an elevated mesial fold carrying 2 or 3 plaits, bordered on each side by 2 or 3 equally strong folds, all of which proceed to the umbo. The beaks are large and erect, and the foramen is elongated.

The young shells are flattened, deltoid, with a curved front, not elevated and fimbriated.

The figured example (f. 15) is more gibbous than usual. Dimensions of the largest example: breadth $\frac{3}{8}$ inch.

Geological position.—Zones of *A. Jamesoni*, Robin Hood's Bay, Peak; *A. capricornus*, Staithes, Hummersea, Huntcliff; *A. margaritatus*, Staithes, Huntcliff, Danby Dale; *A. spinatus*, Upleatham, Staithes (very rare).

Rhynchonella fodinalis, *Spec. nov.*

Pl. XV., fig. 16.

This may be the species alluded to by Young and Bird as *Terebratula depressa*, Sow., which they state has nearly the same form as their *T. compressa* which is amply described by them. The species appears to be new and stands alone among its liassic congeners, but recalls a cretaceous facies presented by such species as *R. depressa*, *R. compressa*, &c.

The shell is transversely obovate, moderately depressed, the dorsal valve convex, the margin rising with a gentle undulation, lateral angles rounded. The whole surface covered with from 25 to 30 small plaits, about 8 of which occupy the elevated mesial region. Beak small, incurved.

Geological position.—Zone of *Am. spinatus* (main seam), Eston, Slapewath, Guisborough (6 exs.).

Rhynchonella capitulata, *Spec. nov.*

Pl. XV., fig. 24.

Shell ovato-triangular, slightly transverse, with an elevated angular mesial fold; anterior third of the shell plaited, 2 to 4 (usually 3) plaits on the mesial fold, and about 5 on each lateral area; the umbones gibbous; from the appearance which the gibbosity presents the shell has been named *capitulata*. Beak thick, small, suberect. The shell never attains any considerable size. The dimensions of the largest specimen, which is represented by fig. 24, are: breadth, $\frac{11}{20}$ inch, height $\frac{8}{20}$ inch, thickness $\frac{7}{20}$ inch.

Geological position—Zone of *Am. spinatus* (main seam where it is very abundant) Eston, Challoner, Upleatham, and Hob Hill Mines.

Rhynchonella Bouchardi, *Davidson.*

Pl. XV., fig. 17.

This small shell, which I refer to *R. Bouchardi*, is very abundant in the grey shales with *Ammonites annulatus*. Fig. 17, though showing its general form, does not represent the charac-

teristic ornament of the shell. There are usually 3 plaits on the depressed mesial fold, flanked on each side by 10, which extend nearly to the umbonal region. The beaks are small, acute, and erect. Its numerous ribs and subglobose shape serve to distinguish it.

Geological position.—Zone of *A. annulatus*, Upleatham, Hob Hill, Hutton, Staithes.

Rhynchonella Jurensis, *Quenstedt.*

1858. 'Jura,' t. xli. fs. 33–35.

Three specimens of a depressed subtriangular shell, with 3 plaits on the mesial fold, obtained from the *Am. Jurensis*-beds at the Peak, are provisionally referred to this species, which bears considerable resemblance to some forms of *R. plicatissima.*

SPECIES EXCLUDED.

Terebratula trilineata, Young and Bird, quoted by the authors from the Alum shale and the Dogger, and by Phillips from the Dogger and Middle Lias, has not occurred to us in any stratum below the ironstone series at the base of the Inferior Oolite; it is there usually accompanied by *Ammonites Murchisonæ* and *Rhynchonella cynocephala.* Doubtlessly *T. punctata* is the species alluded to by the above authors.

Lingula Beani is quoted by Morris, 'Cat. British Fossils,' p. 138, from the Middle Lias of Yorkshire. The type comes from the base of the Inferior Oolite, included by Wright in his Blea Wyke Sands, where it is associated with *Discina reflexa* and *Rhynchonella cynocephala.* The *Lingula* known to us from the Middle Lias has received the name of *L. sacculus.*

Rhynchonella inconstans is recorded by Young and Bird from the ironstone bands in the Alum Shale, p. 232, and is included by Simpson, p. 132, in his list of Yorkshire Lias Fossils. A single example so labelled in the Whitby Museum is a genuine *inconstans*, and resembles in every particular the usual form of the species, so that I am induced to doubt its having been collected from the Lias.

Spirifer medixvus, Simpson, *loc. cit.* p. 133, represents a brachial valve of a palæozoic Spirifer, probably *S. bisulcata.* The type is in the Whitby Museum.

CLASS INSECTA.

BY J. F. BLAKE.

ORDER COLEOPTERA.

Buprestites bractoides.

Pl. XVI., fig. 5.

The above figure exhibits a single elytron of a beetle, which is very similar to Pl. VI., figs. 23, 25, of Brodie's 'Fossil Insects,' which Mr. Westwood refers to the family Buprestidæ, but does not further determine. It occurred in the *annulatus*-shales of Skelton Park Pit. Mr. Brodie's specimens were from the Lower Lias.

ORDER NEUROPTERA.

Chauliodites minor.

Pl. XVI., fig. 6.

Our figure represents two Neuropterous wings, discovered by J. W. Kirshaw, Esq., in the limestone of the *planorbis*-zone at Hotham, to whose kindness we are indebted for the opportunity of figuring them. They are best matched by wings figured, Pl. X., figs. 7 to 9, in the Brodie's 'Fossil Insects,' said by Mr. Westwood to be a species allied to Chauliodes.

CLASS CRUSTACEA.

By J. F. BLAKE.

SUBCLASS MALACOSTRACA.

Eryon Hartmanni, *Meyer*.

Pl. XVI., fig. 7.

1836. 'Nova Acta Acad. Car.' bd. xviii. t. xi. and xii. fs. 2 and 4.

The carapace is not seen in the specimen known—though there are two individuals—but the abdomen so exactly agrees with Meyer's figure, that there can be no doubt of the identification.

Each segment has an elongated tubercle in the centre; the epimera are slightly pointed; the telson is acutely triangular, has two tuberculated ridges on the sides, but none down the centre (in this point differing from Meyer's figure); the caudal plates are broad, with a ridge within the central line; edges rounded showing the fringe; small tubercles conspicuous. The claws are narrow and small.

It differs from *E. Barroviensis* in having no side-tubercles, and being more roughly tuberculated, and is from a different horizon.

Geological position.—Zone of *A. communis*, Whitby (2 exs.). For the opportunity of figuring this fine specimen I am indebted to the kindness of J. W. Kirshaw, Esq., F.G.S., who discovered it.

Pseudoglyphæa Etalloni, *Oppel*.

Pl. XVI., fig. 4.

1862. 'Palæont. Mitth.' t. xiii. fig. 3.
Syn. 1855. *Astacus rostratus*, *Williamsoni*. Simpson. 'Foss. Y. L.' pp. 134, 135 (non Phillips).

Oppel's species has larger tubercles than the Yorkshire forms I refer to it, but otherwise they are fairly coincident in the structure of the carapace and its ornaments. The long claws are exhibited on the figured specimen. They are nearly twice as long as the carapace, their section is somewhat quadrangular,

and they enlarge at the extremity, where the pointed single finger articulates.

Simpson's difference between his *A. rostratus* and *A. Williamsoni* is, that the abdomen in the first is smooth, and in the last has 7 rugose plates. But the smoothness in the first case is due to the trick of some Whitby dealer, who has "improved" the specimen with part of the abdomen of *Eryma lævis*.

Geological position.—Not ascertained. "U. L. Whitby," (Simpson); but the containing nodule looks more like one from the *oxynotus*-beds of Robin Hood's Bay.

Pseudoglyphæa hamifera, *Spec. nov.*

The specimen on which this species is founded is a very broken one, and one-half of the carapace is turned completely round. It shows, however, the characteristic parallel furrows and kidney-shaped prominence of the genus. The latter is narrow, elongated, and in the shape of a hook or clothes' peg, and has above it, in the hollow of its curvature, a rounded knob. The two claws are strong, apparently quadrilateral, and swell at the end, where the small finger articulates.

The above characters assimilate it most to *P. Terquemi* (Oppel) of the Oxford clay, but it does not closely resemble any Liassic form.

Geological position.—Zone of *A. Jamesoni*, Huntcliff (1 ex.).

Glyphea Terquemi, *Oppel.*

Pl. XVI., fig. 2.

1862. 'Palæont. Mitth.' t. xv. fig. 6.
Syn. ? 1854. *G. liasina.* Morris. 'Cat. of Brit. Foss.' p. 108 (non Meyer).

Carapace finely pitted, having a smooth aspect. Only the portion behind the deep transverse furrow visible. This has two furrows, commencing half-way up each side, enclosing between them a club-shaped prominence; furrows divide the portion beyond and outside this into two compartments, of which the outside is nearly quadrilateral. Possibly the same species as *G. liasina*, recorded by Morris from Lias, Yorkshire.

Geological position.—Zone of *A. armatus*, Robin Hood's Bay (1 ex.).

Glyphea lyrica, *Spec. nov.*

Pl. XVI., fig. 1.

Front part of the carapace flat at the top, which is bounded by curved tuberculated ridges, like the sides of a lyre; from these the surface slants downwards at a gentle angle to similar ridges at a lower level, which bound the whole upper surface. An inner pair of ridges also exists, and very scattered tubercles

within them, otherwise the whole is smooth. The part behind the transverse furrows is more imperfect; it has a small eminence a little way down on either side the median line, each of which is bounded by furrows; the outer slants upwards to very near the transverse furrow.

Geological position.—Zone of *A. oxynotus*, in the region of *A. obtusus*, Robin Hood's Bay (1 ex.).

Several crustacean remains have been met with in this zone, but I have only seen this one in a state at all fit for description. Associated also are feet, which may well belong to this species; they are enlarged at the ends, and truncated at the articulation of the small finger.

Eryma lævis, *Blake*.

Pl. XVI., fig. 3.

Syn. 1855. *A. lævigatus.* Simpson, *loc. cit.* p. 135.

A small prawn-like crustacean, which presents, however, the three characteristic furrows on the carapace; the front one pretty plain, the two hinder very slight, and soon uniting. It is very compressed, and the whole, including the abdomen, is perfectly smooth. The length of its carapace is somewhat less than that of the abdomen, whose joints are broad. Legs unknown, associated with the carapace.

I have not adopted Simpson's name, because his only description is "carapace and abdomen smooth, slender," without the genus being ascertained or characters noted that might indicate it.

Geological position.—Zone of *A. oxynotus*, Peak (*in situ*).

[UNDETERMINED SPECIES.]

Astacus Banksii. Simpson, *loc. cit.* p. 135.

The only description is "carapace broad, channelled with many wrinkles; tubercles numerous, small. A robust species, L. L. Robin Hood's Bay." This will obviously not serve to distinguish it. I have not seen the specimen. It may be *Glyphæa Terquemi*.

Numerous crustacean claws occur in many zones; *e.g.*, those of *A. Bucklandi*, *capricornus*, *margaritatus*, and *communis*; but as the generic characters are not taken from these parts, they cannot be satisfactorily named.

SUBCLASS ENTOMOSTRACA.

The Liassic Entomostraca are for the most part undescribed, and scarcely any references to foreign authors are possible. Their minute carapaces are seldom absent from the foraminiferous clays; but they have hitherto attracted but little attention, and

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Bairdia lacryma, *Spec. nov.*

Pl. XVII., fig. 3.

...ated posteriorly and recurved, swollen and ...rly; dorsal side slightly concave, ventral side ...alve larger than the left.

...approach to this shape is presented by *B. siliqua*, Professor Jones in his Memoir on Cretaceous pl. V. fig. 16, which is much larger and more

...sition.—Zones of *A. angulatus* and *A. Bucklandi*.

Bairdia redcarensis, *Spec. nov.*

Pl. XVII., fig. 4.

...more than half as broad as long, not very inflated, ...onvex on the dorsal side, nearly straight, or with a ...gmoid curve on the ventral side.

...rmediate in size and shape between *B. liassica* and

...l position.—Zones of *A. angulatus* and *A. Bucklandi*.

Bairdia elongata, *Spec. nov.*

Pl. XVII, fig 5.

...ce large, long, like a narrow bean; ends nearly alike, ...urved; ventral side slightly concave, dorsal side greatly ...not compressed.

...is the largest species of the genus in these deposits. It ...rom *B. dispersa* in this, and in not being compressed. It ...ossible, however, it may represent its senile form.

...gical position.—Zones of *A. angulatus*. Millington (1 ex.); ...landi, Redcar (1 ex.).

Cythere Blakei, *Jones.*

Pl. XVII., fig. 6.

1872. 'Quart. Jour. Geol. Soc.' vol. xxviii. p. 146.

"Carapace oblong, subcylindrical, with marginal lips at the ..., obliquely rounded in front, contracted and rounded behind. ...what compressed dorsally at the median third; surface ...h, with faint irregular reticulation, and bearing traces of ...tral striæ." The ornament has little or no tendency to run ...lines.

...logical position.—Zones of *A. planorbis*. Cliff (3 exs.); *A. angu-* Redcar (1 ex.).

Cythere Terquemiana, *Jones.*

Pl. XVII., fig. 7.

1872. 'Quart. Jour. Geol. Soc.' vol. xxviii. p. 147.

"Carapace narrow-oblong, incurved on the back by the projection of the anterior hinge, and pinched in between that hinge and the muscle-spot; rounded at the ends, with broad delicate margins, that of the front divided into about eight neat fossets. Surface sculptured with a coarse, irregularly-hexagonal network, about eight meshes to the transverse width of the valve." Elevated on the anterior and postero-ventral portions.

Geological position.—Zone of *A. planorbis*, Cliff (3 exs.).

Cythere triangulata, *Spec. nov.*

Pl. XVII., fig. 8.

The two valves together have a section nearly represented by an equilateral triangle, $\frac{5}{6}$ as long as broad. The sides are swollen, and ornamented with ridges and reticulation, which are very inconspicuous but very uniform. The ventral margin is straight and lipped, and joins the ends in an obtuse angle.

Geological position.—Zone of *A. Bucklandi*, Robin Hood's Bay (8 exs.).

Cythere Moorei, *Jones.*

Pl. XVII., fig. 9.

1872. 'Quart. Jour. Geol. Soc.' vol. xxviii. p. 146.

"Carapace tumid, egg-shaped, with terminal lips and flattened ventral surface, somewhat like a peach-stone in shape and ornament. Surface of the valves reticulate; the meshes rather coarse in the middle, but having a tendency to become longitudinal and parallel on the sides and towards the extremities."

Rather largest anteriorly; interior of large valve showing two small hinge pits, and furrows round the back and front. The ornamentation is very elegant—like parallel irregularly-carved furrows.

Geological position.—Zone of *A. planorbis*, Cliff (3 exs.).

Cythere translucens, *Spec. nov.*

Pl. XVII., fig. 10.

Carapace tumid, but slightly compressed, with flattened ventral surface; posterior end pinched; anterior larger, with an expanded border, except on the ventral side; ornament, a tangled network of ridges, most constant longitudinally, standing up much more than in the last species, which forms the most marked difference between them.

The shells are beautifully transluoent, and show the little structural tubes very well. The inner dorsal edge shows the long crenulated bar of the genus. The figure is wrong.

Geological position.—Zones of *A. Bucklandi*, Redcar (4 exs.); *A. oxynotus*, Market Weighton.

Cythere redcarensis, *Spec. nov.*

Pl. XVII., fig. 11.

Similar in shape to *C. Moorei*, but much smaller, and with an ornament consisting simply of a very regularly pitted surface.

Geological position.—Zone of *A. angulatus*, Redcar (5 exs.).

Cythere arcæformis, *Spec. nov.*

Pl. XVII., fig. 12.

Carapace small, elongated, 2½ times as long as broad; generally resembling an ark shell, *i.e.* the dorsal border is hollowed out between two projecting beaks or ridges; breadth across these ridges equal to or greater than the breadth of the side of the carapace. Seen on the side, it is spatulate, like a polished flint hatchet, growing larger anteriorly. Seen transversely, it appears uniformly covered with pits; but seen lengthways, the intervening spaces range themselves in irregular meshes. The figure is not sufficiently inflated.

This small and remarkable form nearly resembles *C. triangulata*, but differs in being flatter on the side, wider, and more excavated across the hinge, and longer in proportion.

Geological position.—Zones of *A. angulatus* and *A. Bucklandi*, Redcar.

Cytherella ? paupercula, *Spec. nov.*

Pl. XVII., fig. 13.

Carapace narrow, oblong, pinched in towards the middle, largest anteriorly; ends rounded, and provided with lips, which are marked into 8 fossets. The two valves together are nearly as broad as they are high in the centre, making the section nearly square, but it is generally more oval. Ornaments intermediate between those of *Cythere Terquemiana* and *Cytherella circumscripta*. The ridges of the latter, though very inconspicuous, may be traced as slight elevations, but the surface of the carapace is covered with the coarse hexagonal network. It would appear to be, from these characters, a *Cytherella*.

Geological position.—Zones of *A. angulatus* and *A. Bucklandi*, Redcar (6 exs.).

Cytherella circumscripta, *Spec. nov.*

Pl. XVII., 14.

Carapace oblong, half as long again as broad, very compressed; anterior end rounded and provided with lips, posterior end more truncated. The surface is bounded by a strong ridge, which is continuous near the edge round all but the dorsal side, which it joins about a quarter of the distance from the anterior end. On reaching the posterior end of the dorsal side the ridge leaves the circumference, and continues irregularly nearer the centre; another ridge rises from the centre of the posterior end, joining the former, and continuing down the middle of the carapace. Between these ridges the surface is concave, and covered with a rough hexagonal network.

Geological position.—Zone of *A. angulatus*, Redcar (3 exs.).

Cytherella crepidula, *Spec. nov.*

Pl. XVII., fig. 15.

Carapace oblong, oval, half as broad as long; sides straight; posterior side broadly semicircular, slightly oblique, largest and most prominent; anterior side narrowly semicircular, more acute; surface nearly flat, but joining the hinge-line at a right angle. The two valves together form a thick shell like a trimmed brick; sculpturing consists of flat and broad, rather inconspicuous, ridges.

Geological position.—Zone of *A. capricornus*, Huntcliff (2 exs.).

Genus Polycope, *Sars.*

This genus was instituted by Sars, in 1865, for certain living Entomostraca, whose carapace valves presented a circular outline. Besides the species originally constituting it, which has been found fossil in Post-Tertiary beds, other fossil forms are referred to it by Professor Jones from the Carboniferous limestone. These latter appear to me to belong to a different family, and only to bear an accidental resemblance to *Polycope* in their simplicity. The species here recorded from the Lias represents the true form.

Polycope cerasia, *Spec. nov.*

Pl. XVII., fig. 16.

Carapace circular, compressed, small, hinge-area small, ventral side with a produced lip; ornamentation, a series of fine ridges and pits running from back to front, bowing out in the centre; when seen transversely, it appears only irregularly pitted. The hinge-line is straighter than in *P. orbicularis* (Sars).

Geological position.—Zones of *A. angulatus* and *A. Bucklandi*, Redcar.

SUBCLASS PECTOSTRACA.

Pollicipes alatus? *Tate.*

1870. 'Irish Liassic Foss.' fig. 6, p. 23.

A carina attached to *A. armatus* has the ornament of this species, described from scuta, namely, elevated lines parallel to the base. The two fossils being represented by different parts, further comparison is prevented, and there is nothing, therefore, against their being the same.

Geological position.—Sub-zone of *A. armatus*, Peak.

CLASS ANNELIDA.

By RALPH TATE.

Galeolaria socialis, *Goldfuss.*

1836. (*Serpula.*) 'Petref. Germ.' vol. i. t. lxix. f. 12.
Syn. 1865. *Galeolaria filiformis.* Terquem and Piette. 'Lias Inf.' t. xiv. fs. 6, 7, p. 116.

The fossil resembles short lengths of a stout cord of many slender strands.

It is common in the Inferior Oolite of Gloucestershire, but is known in some of the intervening Liassic beds.

Geological position.—Zones of *Am. angulatus*, Cliff, Redcar; and *Am. Bucklandi*, covering the upper surfaces of the limestones of Jenny Leigh's Scar, Redcar.

Serpula limax, *Goldfuss.*

1836. 'Petref. Germ.' vol. i. t. lxvii. f. 12, p. 227.

Geological position.—Zones of *Am. angulatus* and *Am. Bucklandi*, Redcar; *Am. margaritatus*, Huntcliff, Rockcliff; and *Am. spinatus*, Hob Hill, Saltburn.

Serpula lituiformis, *Münster.*

1836. Goldfuss. 'Petref. Germ.' vol. i. t. lxvii. f. 15, p. 228.

Geological position.—Zone of *Am. Bucklandi*, Redcar (1 ex.).

Serpula plicatilis, *Goldfuss.*

1836. 'Petref. Germ.' vol. i. t. lxviii. f. 2.

Geological position.—Zones of *Am. angulatus*, Cliff; *Am. Jamesoni*, Huntcliff, Osborne Rush Pit, Upsall, Robin Hood's Bay.

Serpula deflexa, *Phillips.*

1829. 'Geol. York. Coast,' t. xi. f. 26, p. 158.
Syn. 1836. *Flaccida.* Goldfuss. 'Petref. Germ.' vol. i. t. lxix. f. 7, p. 234.

Geological position.—Zones of *Am. angulatus* and *Am. Bucklandi*,

Redcar; and *Am. Jamesoni*, Robin Hood's Bay. Hitherto known in England as coming from the Inferior Oolite.

GENUS DITRYPA, *Berkeley.*

The genus *Ditrupa* was founded by Berkeley upon the types *Serpula liberata*, Sars, and *Dentalium subulatum*, Deshayes, but the spelling was rectified by Brown in 1849. As represented by the types, it is characterised by a dentaloid shell, and from this circumstance the species have been confounded with *Dentalium*. They differ from *Serpula*, less by their organisation than by their mode of life, because, whilst the first are free, the others are fixed to submarine bodies. Whatever may be the distinctive characters presented by the shell-structure of *Ditrypa* and *Dentalium*, I find that the aperture of a perfect tube of the former presents a thickened and bevelled margin; the tube thickens towards its anterior extremity, whence it is abruptly planed to a sharp edge, as in many *Serpula*-tubes. This character is not presented, so far as I know, by the tubes of the *Dentaliadæ*, and is quite different from the inflation of the body of the tube as exhibited in the genus *Helonyx*. *Ditrypa* is distinguished from *Serpula* in being more or less cylindrical and regularly dentaloid in the typical species, *free*, open at the two extremities. An emended character of the genus, in so far as regards the shell, is —Tube cylindrical, more or less regular, free, open at both ends, smooth, rugose, annulated or longitudinally sulcated; aperture circular, contracted, peristome attenuated.

Ditrypa capitata, *Phillips.*

Pl. XI., fig. 8.

1829. (*Serpula.*) 'Geol. York.' t. xiv. f. 16.

Tube cylindrical, nearly straight, with irregular annulations, imbricating rugæ in the anterior half; posterior smooth or wrinkled longitudinally. A nearly entire specimen from the main seam of ironstone has a length of 3 inches, and a diameter of $\frac{2}{10}$ inch; it agrees with the type which I have examined; and is the one figured.

Geological position.—Zone of *Am. angulatus*, Cliff, Redcar; *A. Bucklandi*, Redcar; *Am. Jamesoni*, Huntcliff (abundant); Upsall, Easby; *Am. spinatus*, Upleatham.

Ditrypa cylindracea, *Terquem and Piette.*

1865. (*Serpula.*) 'Lias Inf.' &c. t. xiv. f. 10.

Geological position.—Zone of *Am. Bucklandi*, Redcar.

Ditrypa globiceps, *Quenstedt.*

Pl. XII., fig. 2.

1858. (*Serpula.*) 'Jura,' p. iii. t. xiii. f. 21.

Tube slender, arcuate, with regular nodes.

Geological position.—Zone of *Am. angulatus*, Redcar.

Ditrypa quinquesulcata, *Münster.*

1836. (*Serpula.*) Goldfuss. 'Petref. Germ.' t. lxvii. f 8

Syn. 1865. *S. pentagona.* Terquem and Piette. 'Lias Inf.' &c. t xiv. f. 13.

1870. *S. subpentagona.* Tate. 'Quart. Jour. Geol. Soc.' vol. xxvi. p. 402.

Cylindrical, arched, with 5 obtuse carinæ, smooth or slightly wrinkled transversely. Usually not exceeding an inch in length, but attains to two or three times that dimension.

Geological position.—Zones of *Am. Bucklandi*, Redcar; *Am. oxynotus*, Robin Hood's Bay; *Am. Jamesoni*, Robin Hood's Bay and Peat, Huntcliff, Upsall, Wood End, near Ayton; *Am. capricornus*, Hummersea; *Am. margaritatus*, Huntcliff; *Am. spinatus*, Eston.

Ditrypa circinata, *Tate.*

Pl. XIV., fig. 11.

1873. 'Quart. Jour. Geol. Soc.' vol. xxix. p. 350.

Tube about the dimensions of *Dentalium giganteum*, but the posterior one-third forms a semicircle or more, and the whole length presents nodular enlargements at distant and variable intervals; aperture circular with a bevelled margin. Apical portion of tube subquadrangular or pentagonal, the rest rounded.

Geological position.—Zones of *Am. oxynotus*, Robin Hood's Bay; *Am. Jamesoni*, Huntcliff, Coatham, Robin Hood's Bay (very common); *Am. capricornus*, Huntcliff; *Am. margaritatus*, Huntcliff; *Am. spinatus*, Northcote, Eston, and Upleatham Mines (rare).

The thick tests of the large oysters in the upper part of the Middle Lias have been the habitats of an excavating annelid, the casts of whose furrows are displayed by the natural weathering of the shell. They are about the thickness of a fine sewing-needle of an inch or more in length, and are interposed between the laminæ of the shell. I have observed them in *Ostrea submargaritacea* from the *A. spinatus*-beds, and in *Ostrea cymbium* from the *A. margaritatus* and *A. capricornus*-beds.

CLASS ECHINODERMATA.

By J. F. BLAKE.

The chief remains of this class belong to the Orders of the Asteroidea and Crinoidea, the Echinoidea being rarely met with.

Parkinson in 1811 figured portions of two species of Crinoids from the Yorkshire Lias, but did not name them, and in the same way Young and Bird noticed, in 1822, two Crinoids and one Asteroid. In Phillips's 'Geology of Yorkshire' in 1829, we have the first name assigned, namely, that of *Ophiura Milleri*, and he quotes *Pentacrinus caput-medusæ* (a recent species), and *P. briareus* described by Miller, and also figures a smooth echinoid spine. To these in 1836 Williamson added *Luidia Murchisoni*, in a paper in the 'Annals and Magazine of Natural History.' In 1847 Charlesworth figured in the London 'Geological Journal' a new Pentacrinus, *P. gracilis*, and next year M'Coy added *P. dichotomus* in the 'Annals and Magazine of Natural History.' In 1848 Forbes described in the Memoirs of the Geological Survey, Decade III., *Uraster Gaveyi* and *Astropecten Hastingiæ*. In Simpson's oft-quoted work in 1855 we find ten species of this Class recorded, I cannot say described, three of which, one being a *Cidaris*, had not been noticed before, though they have been subsequently described. Oppel recorded the occurrence of *P. scalaris* in 1856. In the volumes of the Palæontographical Society for 1863 and 1866 the Asteroidea and Ophiuroidea were subjected to a critical revision by Dr. Wright who enumerates seven, of which two only, *Plumaster ophiuroides* and *Ophiolepis Murravii*, had not been noticed in Yorkshire before under one name or another. Among the Crinoids, Phillips in his recent edition (1875) corrects the name *P. caput-medusæ* to *Extracrinus subangularis*, bringing the total of recognised species, excluding synonyms and erroneous determinations, to 14. I recorded one additional form in my paper on the Infralias in Yorkshire in 1872, and we now add 9, making a total of 24, leaving some forms undetermined.

ORDER ECHINOIDEA.

Cidaris Edwardsii, *Wright.*

1856. 'Brit. Foss. Echinodermata, Pal. Soc.' pl. i. fig. 1.
Syn. 1829. Phillips. 'Geol. York.' pl. xiii. fig. 17.
1855. *Echinus antiquus* and *obsoletus*. Simpson. 'Fossils, Y. L.' p. 137.

Simpson's names are applied to test and spines respectively in

the Scarborough Museum, which have been recognised by Dr. Wright as belonging to his species. I have no doubt that the remains of spines found in the various beds recorded below may possibly belong to some as yet unknown form.

Geological position.—Zones of *A. planorbis*, Eston Gypsum Pit; *A. angulatus*, Redcar, Eston Gypsum Pit; *A. Jamesoni*, Huntcliff (tooth); *A. capricornus*, Huntcliff, Hummersea, Skinningrove (test); *A. margaritatus*, Rockcliff (plate and spine).

Cidaris amalthei, *Quenstedt.*

1858. 'Jura,' pl. xxiv. figs. 42–44.

The spines are papillated.

Geological position.—Zone of *A. spinatus*, Upleatham, Eston.

Rhabdocidaris, *sp.*

Geological position.—Zone of *A. spinatus*, Eston (spine).

Hemipedina Tomesii, *Wright.*

18 0. 'Brit. Foss. Echinodermata,' p. 457 (woodcut).

Geological position.—Zones of *A. planorbis*, Cliff (test), Eston Gypsum Pit (spine); *A. angulatus*, Cliff (teeth and spines), Eston Gypsum Pit, Redcar.

Hemipedina, *sp.*

Some slender spines about 3 inches long are found in the *Jamesoni*-beds at Peak. Their extreme length seems to separate them from known species, but new ones cannot be satisfactorily founded on spines alone.

Pseudodiadema Slateri, *Spec. nov.*

A small species whose shape and ornaments correspond very well with those of *Hemipedina Jardinii* (Wright), but which is proved to be a Pseudodiadema by its crenulated bosses. I name it after H. H. Slater, Esq., its discoverer.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay.

ORDER ASTEROIDEA.

Uraster carinatus, *Wright.*

1863. 'Brit. Foss. Echinoderms,' pl. ii. fig. 1.
Syn. 1855. *Asteria media.* Simpson. 'Foss. Y. L.' p. 135.

This seems to be the *Uraster Gaveyi*, recorded by Forbes. I have no reason to believe that both occur. The fossil in the Scar-

borough Museum to which Simpson's name was given belongs to this species.

Geological position.—Probably zone of *A. capricornus*, Boulby.

Tropidaster pectinatus, *Forbes.*

1850. 'Memoirs of the Geol. Sur.' decade iii. pl. iii.
1863. Wright, *loc. cit.* pl. iii. figs. 1, 2, 3.

This has not been previously noticed from Yorkshire.

Geological position.—Zone of *A. capricornus*, Staithes, Hummersea.

Luidia Murchisoni, *Williamson.*

1836. 'Magazine of Nat. Hist.' vol. ix. p. 425.
1863. Wright, *loc. cit.* pl. v. fig. 2.
Syn. 1855. *Solaster polynemia.* Simpson, *loc. cit.* p. 135.

A specimen of this species is in the Scarborough Museum. This, the type, and one other are all that we know to have yet occurred.

Geological position.—Zone of *A. capricornus*, Peak, Robin Hood's Bay, Huntcliff.

Plumaster ophiuroides, *Wright.*

1863. 'Brit. Foss. Echinoderms,' pl. v. fig. 1.

Geological position.—Probably zone of *A. capricornus*, Skinningrove (1 ex.).

Astropecten Hastingiæ, *Forbes.*

1848. 'Memoirs of the Geol. Sur.' vol. ii. pt. ii. p. 478.
1863. Wright, *loc. cit.* pl. vi. figs. 3, 4.

The original specimen may now be seen in the Museum of Economic Geology, London.

Geological position.—Zone of *A. capricornus*, Boulby (2 exs.).

[*Astropecten Orion* and *A. arenicolus*, catalogued by Morris as from the Lias of Yorkshire, belong to the Kelloway Rock.]

ORDER OPHIUROIDEA.

Ophioderma Milleri, *Phillips.*

1829. *Ophiura.* 'Geol. York,' pl. xiii. fig. 20.
1855. Simpson, *loc. cit.* p. 136.
1866. Wright. 'Brit. Foss. Echin.' pl. xvi. figs. 2–4.
Syn. 1822. *Asterias cf. spherulata.* Young and Bird. 'Geol. Sur.' p. v. fig. 6.

Although this was the earliest figured and noticed, and therefore probably common, it is now very rare.

Geological position.—Zones of *A. capricornus*, Rockcliff, Staithes; *A. margaritatus*, Huntcliff.

Ophioderma Gaveyi, *Wright.*

1854. 'Annals and Mag. of Nat. Hist.' vol. xiii. pl. xiii. fig. 1.
1866. 'Brit. Foss. Echin.' pl. xv. figs. 1-3.

Not noticed from Yorkshire, but if distinct from the next, certainly present.

Geological position.—Zones of *A. Jamesoni*, Robin Hood's Bay; *A. capricornus*, Staithes.

Ophioderma carinata, *Wright.*

1866. 'Brit. Foss. Echin.' pl. xvi. fig. 1.
Syn. 1855 ? *Ophiura gracilis.* Simpson, *loc. cit.* p. 136.

It seems doubtful if this be really distinct. Specimens of *O. Gaveyi* vary both as to the strength of the "keel" and the size of the disc; in none, however, is it so small as in that figured by Dr. Wright. Simpson's type in the Scarborough Museum is nearest to this, and imperfect specimens from the zone of *A. Bucklandi*, Marske, may belong here.

Geological position.—Zone of *A. capricornus*, Staithes.

Ophiolepis Murravii, *Forbes.*

1843. Forbes. 'Proc. Geol. Soc.' vol. iv. p. 233.
1865. Wright, *loc. cit.* pl. xiv. figs. 1, 2; pl. xvii. figs. 2, 3, 4.

Not one of the rarest forms.

Geological position.—Zone of *A. capricornus*, Staithes, Hunt-cliff.

Ophiurella Columba, *Spec. nov.*

Pl. XVI., fig. 11.

The specimen on which this is founded is unfortunately waterworn, and therefore it is doubtful how far its characters may be correctly traced. It is not, however, possible to confound it with any other Liassic species.

It is very like *Ophiurella Griesbachii*, Wright, l. c. pl. XVIII., figs. 3, 4, but differs from it in the more open shape of the buccal plates, in being larger, and in the different direction and shape of the side ossicles of the arms.

It exhibits the characters of the genus in the small side species scarcely to be distinguished, but not in the smallness of the disc; but neither does *O. Griesbachii* in this respect, whose disc is said to be small, being $\frac{7}{18}$ the length of the arms, while in *Ophiolepis Murravii* it is said to be large when it is $\frac{7}{18}$ the length of the arms! Perhaps both *O. columba* and *O. Griesbachii* should be referred to another genus.

Disc pentagonal, about $\frac{2}{5}$ the length of the arm; ventral ray plates cruciform (? by wear); laterals long, narrow, and oblique, the whole having the appearance of a bird in flight; spines

small; buccal opening an obtuse-angled star; length of arm $1\frac{3}{4}$ inch.

This specimen is in a boulder, and shows the ventral side.

Geological position.—Probably *capricornus*-zone, Staithes.

ORDER HOLOTHUROIDEA.

Pl. XVII., figs. 42, 43.

To some animal of this Order I refer numerous small spines or hooklets, met with among the Entomostraca and Foraminifera. Terquem, who first discovered them in the Lias of Metz, called them Foraminifera, but he afterwards (Terquem and Jourdy, 'Mém. Soc. Géol. Fr.,' 2nd ser., vol. IX., p. 145) recognised them as Echinoderm spines and referred them to *Astrophyton*. They are long, variously-curved, smooth spines, ending at the base in a ring with a narrow cross-bar. This structure would not admit of their being jointed to any ossicle, and shows they must have been imbedded in soft flesh. They are therefore most probably Holothuroid spines, such being met with in that Order. This is the more likely as nothing is found associated with them that could be the remains of a hard-covered animal to which they might belong.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* and *A. Bucklandi*, Redcar.

ORDER CRINOIDEA.

Pentacrinal remains are very common in the lower beds, but specimens which exhibit the characters of the cup, associated with the stems, are very rare. It has been the habit, however, to name species by their stems, and in some instances to admit of so much variety in this respect under one name as to make such names quite useless. The nomenclature here used is based for the most part on stems, and on the assumption that they do not vary widely, as I have not found them to do so.

Pentacrinus psilonoti, *Quenstedt.*

1858. 'Jura,' t. vi. fig. 7.

Joints of column narrow (20 to an inch), swollen, edges rounded, with small pits between them in the re-entering angles; joints all alike, or more swollen at irregular intervals.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Cliff, Redcar; *A. Bucklandi*, Redcar.

Pentacrinus tuberculatus, *Miller.*

1821. 'Nat. Hist. of the Crinoidea,' p. 64.
Syn. 1855. ? *P. caput-Medusæ*. Simpson, *loc. cit.* p. 136.

The figures of Mr. Miller are very characteristic. He

observes that this species is very characteristic of a bed of Lias, near the top of the formation (? near the top of its exposure due to the *Bucklandi* limestones). It is always quoted, on the continent, as characteristic of a "tuberculatus-bett" at the base of the zone of *A. oxynotus*. These I so call have sharp angles, and narrow segments (24 to an inch), whose surfaces are flat, and all of the same size, side branches to every six.

Geological position.—Zones of *A. Bucklandi ?* Redcar (head); *A. oxynotus*, Robin Hood's Bay, stems abundant.

Pentacrinus basaltiformis, *Miller.*

1821. 'Nat. Hist. of Crinoids,' p. 62.
1855. ? Simpson, *loc. cit.* p. 136.

Column broad jointed, with no re-entering angles, or only very obtuse ones when young.

Geological position.—Zones of *A. angulatus*, Redcar, W. Coatham; *A. Bucklandi*, Redcar, Marske; *A. oxynotus*, Robin Hood's Bay.

Pentacrinus scalaris, *Goldfuss.*

Pl. III., fig. 6.

1833. 'Petref. Germ.,' t. lii. fs. 3, *a*, *b* (non *c–h*, non t. lx. fig. 10).
Syn. 1852. ? *Punctiferus*. Quenstedt. 'Handbuch der Petref.' t. lii. fs. 41–47.

Goldfuss has figured so many forms under this one name that it has been applied to several species. He did not prove them to be varieties of one species, as they came from several horizons. Quenstedt ('Jura,' tab. XIII., figs. 52–7) has given currency to the use of the name for one form, which is probably what I have called *P. tuberculatus*. Austin ('Crinoidea,' p. 120) identified it with his *P. Millerii*. Oppel quotes this species from the "*raricostatus*-beds" of Robin Hood's Bay, but it is impossible to know which he means. I restrict the name to the first two, or possibly three, of Goldfuss's series, and characterise it as follows:—

Column stout, joints narrow, 20 to an inch, re-entering angles very obtuse; each joint is sharply carinated in the central zone, with a regular row of tubercles on each side, every fourth joint swollen; some of the keels are themselves crenated.

This is probably the form quoted as *P. punctiferus*, Quenstedt.

Geological position.—Sub-zone of *A. armatus*, Robin Hood's Bay.

Pentacrinus Millerii ? *Austin.*

1851. Crinoidea, pl. xvi. fig. 1.
1855. ? *Basaltiformis*. Simpson, *loc. cit.* p. 136.
Syn. 1858. *Scalaris*. Quenstedt. 'Jura,' t. xiii. figs. 52–7.

This name I select as the nearest representative for some

stems which are moderately common in the lower beds of the Middle Lias, bearing considerable resemblance to *P. psilonoti;* the joints are not swollen, however, but flat and wider (15 to an inch), but they have a small perforation between each in the re-entering angle. The columns are arcuate. They appear to be the *P. scalaris* of Quenstedt. *Millerii* unfortunately is from the Inferior Oolite. These may be, for all I know, the *adult* stems of *P. gracilis*, but their commonness demands for them a name.

Geological position.—Zone of *A. Jamesoni*, Robin Hood's Bay, Huntcliff; *A. capricornus*, Huntcliff.

Pentacrinus interbrachiatus, *Spec. nov.*

Pl. III., figs. 5, 8.

Column moderately stout, angles very sharp, so that *alternate* divisions appear to make a perfectly flat surface, out of which the intermediate division stands; joints narrow, 20 to an inch. Each third one is more swollen and broader, and the one next to it is most indented in the re-entering angle.

The primary joints of the calyx are triangular and small, and fit in between the re-entering angles of the uppermost joint of the column, nearly approaching the character of the genus *Extracrinus*. They are followed by two others before bifurcation, both much larger than the first, so as to meet outside the angles of the central plate. Arms equal, composed of very irregular joints, about 15 before dichotomising into 2 equal hands.

From the dorso-central plate, on each side of each angle is a small extra arm, of numerous minute joints—a pair of these running up between the large arms. This last character is the most striking distinction of the species.

Geological position.—Zone of *A. capricornus*, Huntcliff.

Pentacrinus gracilis, *Charlesworth.*

1847. 'London Geol. Jour.' pl. ix.
1855. Simpson, *loc. cit.* p. 136.
Syn. 1851. *P. Johnsonii.* Austin. 'Crinoidea,' pl. xv. fig. 1.

Column very slender, joints nearly round, arms not quickly dividing. The small stems and arms of this species, if separate, would easily be taken for the finer branches of other forms.

Geological position.—Zone of *A. margaritatus*, Staithes, Marske.

Extracrinus britannicus, *Schlotheim.*

1820. (*Pentacrinus.*) 'Petrefactenkunde,' p. 328.
Syn. 1821. *P. briareus.* Miller. 'Nat. Hist. Crinoids,' p. 56.
1855. Simpson, *loc. cit.* p. 136.

As Schlotheim referred to Parkinson's figure, Vol. II., Pl. XVIII., figs. 1-3, his name has undoubted precedence, and should be used.

Geological position.—Zones of *A. annulatus*, Skelton Park; and *A. serpentinus*, Whitby.

Extracrinus dichotomus, *M'Coy.*

1848. (*Pentacrinus.*) 'Annals and Mag. of Nat. Hist.' 2nd ser. vol. iv. p. 406.

Its author describes this species as resembling in every respect *E. britannicus*, except in being smaller and having the arms all of uniform size, and the hands and fingers also uniform, instead of the branches given off being smaller. Austin says that this is a character distinguishing the genus *Pentacrinus*, as compared with *Extracrinus*, at the same time that it seems to me doubtful if this is more than a varietal group of the last species.

Geological position.—Unknown "slab of lias shale," possibly zone of *A. serpentinus*. Whitby.

Extracrinus subangularis, *Miller.*

1821. 'Nat. Hist. of Crinoidæ,' p. 59.

Geological position.—Zones of *A. Bucklandi*, Redcar (Phillips); *A. margaritatus*, Robin Hood's Bay (a doubtful identification).

CLASS ACTINOZOA.

By J. F. BLAKE.

No species of corals have hitherto been recorded from the Lias of Yorkshire, except two of the following, catalogued by myself in 1872, and the coral fauna still remains very limited, and is confined to two zones near the base of the formation.

Montlivaltia Haimei, *Chapuis and Dewalque.*

1853. 'Foss. de Luxemb.' pl. xxxviii. fig. 5.
1867. Duncan. 'Brit. Foss. Corals,' pl. x. figs. 24–32.

A depressed, button-shaped coral, with a convex upper surface; septa very fine and granulated.

Geological position.—Zones of *A. angulatus*, Cliff, Millington, Redcar (abundant); *A. Bucklandi*, Redcar.

Montlivaltia Guettardi, *Blainville.*

1830. 'Dict. des Sc. Nat.' t. lx. p. 302.
1853. Chapuis and Dewalque, *loc. cit.* p. xxxviii. fig. 6.
1868. Duncan, *loc. cit.* pl. xii. figs. 10–14.

A short cup-shaped coral, with conspicuous septa; epitheca wrinkled.

Geological position.—Zone of *A. Bucklandi*, Redcar (abundant).

Montlivaltia polymorpha, *Terquem and Piette.*

1865. 'Lias Inf. de l'Est de la France,' pl. xvi. figs. 17-21.
1867. Duncan, *loc. cit.* pl. vii. figs. 14, 15, pl. viii. figs. 1-4.

Elongated and cylindrical, generally attached.

Geological position.—Zone of *A. angulatus*, Redcar (8 exs.).

Septastræa excavata, *Fromentel.*

1860. Martin. 'Infralias de la Côte-d'Or,' pl. viii. figs. 1–5.
1867. Duncan, *loc. cit.* pl. i. figs. 6, 7.

The only compound coral of our Lias.

Geological position.—Zone of *A. angulatus*, Cliff (2 exs.), and one in a block found at Redcar.

CLASS PORIFERA.

No certain remains of sponges have been found, but in the *oxynotus*-beds at Robin Hood's Bay occur what appear to be casts in pyrites of the interior of *Siphonia*, or pseudo-morphs of a *Siphonia* itself. They are in the form of a short truncated cone, excavated at the top, swollen round the base, in the centre of which is a short thin stem.

INCERTA SEDIS.

Under this head we may mention certain forms of whose nature we are ignorant.

1. The pointed organisms called by Quenstedt ('Jura,' pl. XXIV. fig. 59) *Onychites numismalis*, which we have met with in the *Jamesoni*-beds at Peak.

2. Segments of what may be Crinoid arms, consisting of flat pieces, with generally one more or less central, and several exterior perforations, as in pl. XVII., fig. 40, often arranged in a cruciform manner. They are of minute size, and exceedingly abundant among the microzoa.

3. Brown horny teeth or hooks, broken off irregularly below, as in pl. XVII., fig. 41, which may have very possibly belonged to the arms of Belemnites, or rather perhaps to naked Cephalopods, as they occur in the lower beds, where Belemnites are rare. They are about $\frac{1}{40}$ inch in length.

CLASS RHIZOPODA.

By J. F. BLAKE.

ORDER FORAMINIFERA.

Like the Entomostraca and other Microzoa, the Foraminifera of the Lias, as of other Jurassic rocks, have been very much neglected by geologists. Their abundance and beauty as microscopic objects might have attracted attention, but for the difficulty of their nomenclature and the little value they have been thought to possess as characteristic fossils. A few words must be said on these two points in connection with each other.

With regard to their nomenclature there are two distinct schools, one might almost say: one, the English, who include a long series ranging through all time under one species; the other, the Continental, who treat differences in Foraminifera as they would in other shells, and give new names to all that can be distinguished from each other in one formation only.

The principle of the English school, unfortunately a too limited number, is that "the element of time is to be excluded from the definition of a species." Certainly the difficulties arising from the long persistence and intimate connection of fossil forms reach their maximum among the lowly organised Foraminifera, and we have to face the question whether we will call a Silurian and a recent form by the same name; and it is a crucial question as to the naming of fossils in general, for we must follow the same principle in every case. If we do not believe in the continuity of life, but think that each species has a something that cuts it off from all others, then we shall be able to attach some meaning to the words "a true species," and understand how a whole series of forms, placed by some under different genera, and almost families, can be called by others "but one species;" for where the gaps are bridged, however slightly, there can be no separation of species in this sense. But if, on the other hand, we conceive that there has been a gradual development of life, by what laws we may not know, then the existence of passage forms is to be expected in all parts of the animal kingdom, and most so in the abundant and simple Foraminifera, and it would be a mere playing upon words to call this a "species," that a "variety," and that a "sub-variety," merely on account of our knowledge or otherwise of these passage forms. Our

names should be merely symbols for certain forms, and should not be considered as predicating any supposed want of genetic connection with other forms. Forms are found to vary with time, place, and circumstance; and though the Foraminifera seem least affected by the two former, and sometimes almost inappreciably by the first, which has so marked an influence on higher forms, yet as much importance should be attached to the changes affected by one cause as by another, when they are determinate and constant. If two forms are undistinguishable though separated by a long interval of time, the principle of time not forming an element in the definition of a species should prevent us from using two names; but if there is any constant difference, the fact of their being removed from each other in time may make it of sufficient importance to require recognition by a name, though it might not be so, if they were inhabitants of the same sea.

The Foraminifera therefore of the Lias are not here jumbled together under a few names of recent forms, with the remark that they all very much resemble each other; but I have taken names from the described forms of any age when they fairly represent the Liassic forms; but when there is any sufficiently distinct character I have used the names of Terquem or Bornemann, who have perhaps given too many, and in some cases unnecessary ones.

There are no previous authors on Foraminifera from the Lias of Yorkshire, and even from that of England the only contribution of importance is that of Mr. H. B. Brady, in Moore's 'Middle and Upper Lias of the South-west of England, 1866,' except notices that forms described from other formations occur also in the Lias description of single specimens, and Mr. Wright's list of those found in the Lias of Belfast. For this reason I have thought it worth while to give illustrations even of well-known forms, although by figuring less distinct varieties the number could have been largely increased.

Liassic Foraminifera, though belonging to forms which are found in beds of many ages, have in their assemblage a distinct facies. The most common species are—*Involutina liassica*, *Lingulina tenera*, its variety *Lingulina striata*; *Nodosaria raphanistrum*, *Dentalina communis*, *D. Breoni* and *D. funiculosa*, *Frondicularia intumescens* and *F. sulcata*, *Marginulina raphanus* and *M. inæquistriata*, *Cristellaria recta* and *C. Bronnii*, and *Polymorphina fusiformis* and *Pulvinulina elegans*, most of them belonging to the Family Lagenida. The other families are feebly, if at all, represented, and we miss the Miliolines and Rotalines, so numerous in more recent deposits. The latter however occur rarely, and were found commonly in the Trias of Chellaston (Jones and Parker, Q. J. G. S., vol. XVI. p. 452) in one of their simplest varieties; and these facts would seem to indicate, if we are to be guided by the law of the lowest type appearing first, that we should regard the Imperforate group as higher

than the Perforate—indeed the restriction of the nutritive function to one portion of the body is an advance upon its vegetative repetition.

The chief repositories of the Foraminifera are the soft clays of the various zones. These are washed down with painter's brush and basin till the washings are clean, and the Microzoa are picked out of the dried residue, after passing through a sieve 47 to the inch, with a camel's-hair brush, under a Binocular with $\frac{2}{3}$ in object glass. The smaller forms, and it is believed even the smallest present, are thus detected, while a few larger ones are picked out of the portion which does not pass the sieve. All the figures are drawn to the same scale, so that their relative sizes may be seen at a glance. The harder shales and rock beds have yielded scarcely any, though searched, except when soft bands intervene, as in the *capricornus* shales of Huntcliff. No Microzoa have been detected in the main seam of ironstone. Nor have we been much more successful in the true Upper Lias: the most promising portions of the alum shale, jet rock, and *Jurensis*-beds have been washed down with little result. We have already noticed that in going downwards, the Foraminifera suddenly cease with the beds associated with *Pleuromya Crowcombei*.

SUBORDER IMPERFORATA.

Cornuspira infima, *Strickland, sp.*

Pl. XVIII., fig. 1.

1846. 'Quart. Jour. Geol. Soc.' vol. ii. p. 30.

Whorls cylindrical, evolute, without ornament, occasionally constricted, centre spherical. The shell, when preserved, is glassy in appearance, and this may therefore be a *Spirillina*, but no perforations of the wall can be seen. We cannot expect to make out the shell structure of so small and possibly altered organisms.

The central sphere distinguishes this from *C. involvens* (Reuss) and *C. liasina* (Terq.).

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar; *A. Bucklandi*, Redcar; *A. annulatus*, Hob Hill.

Miliola Scheibersii, *D'Orbigny.*

Pl. XVIII., fig. 2.

1846. 'Foram. Foss. de Vienne,' t. xix. figs. 22–24.

A coarse form, showing only two chambers on one side with coarse ribs, rather inflated below. It differs from *M. liasina*,

Terquem, in its too coarse ribs, but does not agree very perfectly with D'Orbigny's figure.

Geological position.—Zone of *A. planorbis*, Cliff (1 ex.).

Trochammina irregularis, *D'Orbigny.*

Pl. XVIII., figs. 3, 4.

1848. 'Prodromus,' vol. ii. p. 111.
1862. Carpenter. 'Introd. to the study of Forams.' pl. xi. figs. 6–10.
1866. Brady. 'Moore's Mid. and Up. Lias, S.E. England,' pl. i. figs. 1–3.

Shell adherent, consisting of several hemispherical chambers, connected by narrower passages; texture fine. Different arrangements and forms of the chambers occur; some are lageniform, some bifurcate, and others like *Vertebralina.*

Geological position.—Zone of *A. planorbis*, Cliff.

Trochammina incerta, *D'Orbigny.*

Pl. XVII., fig. 17.

1839. 'Foram. de Cuba,' pl. vi. figs. 16, 17.
1857. Williamson. 'Monog. Brit. For.' fig. 203.

Very arenaceous, somewhat like a *Cornuspira.*

Geological position.—Zones of *A. annulatus*, Hob Hill (1 ex.); *A. communis*, Boulby (1 ex.).

Trochammina inflata, *Montfort.*

Pl. XVII., fig. 18.

1808. 'Conchyl. Systématique.'
1862. Carpenter. 'Introd. to Study of Forams.' pl. xi. fig. 5.

Turbinate, like a *Rotalia*, last chambers occupying the whole of the under side.

Geological position.—Zone of *A. communis*, Boulby (1 ex.).

Lituola agglutinans, *D'Orbigny.*

Pl. XVII., fig. 40.

1846. 'Foram. Foss. de Vienne,' pl. vii. figs. 9, 10.
1869. Parker and Jones, *loc. cit.* pl. xx. fig. 47.

Geological position.—Zone of *A. communis*, Boulby (1 ex.).

Lituola globata, *Spec. nov.*

Pl. XVIII., fig. 5.

Syn. ? 1870. *Webbina infraoolitica* (pars). Terquem. 'Mém. sur les Foram. oolitiques,' pl. xxix. fig. 24.

Very rough and arenaceous, and of free habit. These are the characters of the genus *Lituola;* but the aspect of the shell is

more that of *Globigerina*, consisting of globular chambers, situated irregularly about a centre.

The mimicking by arenaceous species of the forms of the other two families is so widespread, that the families would appear to be more closely connected than is usually supposed.

Geological position.—Zones of *A. planorbis*, Cliff (3 exs.); *A. annulatus*, Hob Hill (2 ex.).

Involutina liassica, *Jones, sp.*

Pl. XVIII., figs. 6, 6*a*.

1853. 'Proc. Cotteswold Club,' vol. i.
Syn. 1863. *Jonesi, Deslongchampsi, polymorpha, limitata.* Terquem. 'Mém. sur For. du Lias,' pl. vi. fig. 22, pl. x. figs. 22–24.

Large, very rough and arenaceous. Similar in form to *Cornuspira*, but having the central part of one side covered with a rough or tuberculated overgrowth, leaving the outside whorl alone visible. On the other side they all appear with angular margins. Terquem says the chambers are divided by semi-partitions, but of these I can find no sign.

The genus seems to be peculiar to the Lias, where it grows to great size, and is abundant.

Geological position.—Zones of *A. angulatus* and *A. Bucklandi*, Redcar.

SUBORDER PERFORATA.

Lagena lævis, *Montfort, sp.*

Pl. XVIII., figs. 7, 7*a*.

1808. 'Conchyl. System.'
1865. Jones, Parker, and Brady. 'For. of Crag' (Pal. Soc.), 33.
Syn. 1857. *Vulgaris.* Williamson. 'Rec. Foram. Great Britain,' pl. i. fig. 5.

The commonest of the Liassic *Lagenæ* cannot be distinguished, except by its small size, from the living form. It is smooth, elongate, and short-necked. These are among the smallest of the forms; and Terquem, who does not record it, may have missed it from its minuteness. A remarkably depressed form is represented in fig. 7*a*.

Geological position.—Zones of *A. planorbis*, Cliff; *A. Bucklandi*, Redcar.

Lagena natrii, *Spec. nov.*

Pl. XVIII., fig. 8.

This belongs to the '*sulcata*' group, but is more cylindrical in form and rougher in appearance than any recent shell. When

not too rough, sulcations may be seen, and the enlargement at the end of the neck. It reminds one of a soda-water bottle.

Geological position.—Zone of *A. planorbis*, Cliff.

Lagena elongata, *Ehrenberg.*

Pl. XVIII., figs. 9, 9*a*.

1854. 'Microgéologie,' pl. xxv. A.
Syn. 1858. *Oolina fusiformis, lanceolata, acicularis, lagenalis, simplex.* Terquem, *loc. cit.* pl. vii. fig. 1; pl. i. figs. 1–3; pl. v. figs. 1, 2.

A narrow tube swelling in the middle and open at both ends. The position and amount of the swelling are variable, and give rise to Terquem's different named forms, each represented by only one specimen. The end is also sometimes swollen (fig. 9*a*)—perhaps always, and then often broken off.

Geological position.—Zones of *A. planorbis*, Cliff (many); *A. angulatus*, Redcar (1 ex.); *A. Bucklandi*, Redcar (3 exs.).

Lagena ovata, *Terquem.*

Pl. XVIII., fig. 10.

1858. 'Mém. sur les Foram. du Lias,' pl. i. fig. 2, and pl. v. fig. 3.

This differs in shape from all other *Lagenæ*, being flattened and acuminate below, like a plasterer's trowel. The neck is short.

Geological position.—Zone of *A. planorbis*, Cliff (1 ex.).

Glandulina humilis, *Römer.*

Pl. XVIII., fig. 11.

1841. 'Verst. der Norddeutsch. Kreide,' pl. xv. fig. 6.
1865. Brady in Moore's 'Mid. and Up. Lias,' pl. i. fig. 5.
1860. Jones and Parker. 'Quart. Jour. Geol. Soc.' vol. xvi. pl. xii. fig. 6.
Syn. 1854. *Rotundata, major.* Bornemann. 'Liasformation v. Göttingen,' pl. ii. figs. 1, 2, 4.
1860. *Glans.* Jones and Parker, *loc. cit.* fig. 7.
1862. *Metensis, oviformis.* Terquem, *loc. cit.* pl. v. fig 9; pl. vii. fig. 4.

The chambers rapidly enlarge, are smooth and rotund, with the margins slightly constricted. It is a common and long-continuing form, and is closely allied to *G. lævis*.

Geological position.—Zone of *A. capricornus*, Saltburn.

Glandulina cuneiformis, *Terquem.*

Pl. XVIII., fig. 12.

1866. *Loc. cit.* pl. xix. fig. 7.

Remarkable for its elongation and complete absence of constrictions. It resembles a long bullet. Its partitions are seen

as thin circular lines. The end is surmounted by a low truncated cone, having the aperture at the top.

Geological position.—Zone of *A. angulatus*, Redcar (1 ex.).

Glandulina paucicosta, *Römer.*

Pl. XVIII., fig. 13; pl. XIX., figs. 1, 1*a*.

1841. 'Verst. Norddeutsch. Kreide,' pl. xv. fig. 7.
1865. Brady, *loc. cit.* pl. i. fig. 8.
Syn. 1854. *Quinquecostata, sexcostata, septangularis, melo, abbreviata, costata,* and *Nodosaria novemcostata.* Bornemann, *loc. cit.* pl. ii. figs. 6–12.

This straight-ribbed *Glandulina* is so well marked that it is surprising that Bornemann should have made so many species of it, as it acquires more ribs according to its nourishment and size. The first chamber is sometimes enlarged and without costæ (Pl. XVIII., fig. 13), the remainder are without constrictions, not numerous, with 5 to 9 ribs. There is a certain obliquity about some that leads on to *Marginulina*. Pl. XIX., fig. 1*a*, doubtfully belongs here. It may be *Dentalina cuneiformis*, Terquem ('For. Ool.,' Pl. XXIV., fig. 24).

Geological position.—Zones of *A. planorbis*, Cliff (1 ex.); *A. Bucklandi*, Redcar (many).

Lingulina tenera, *Bornemann.*

Pl. XVIII., figs. 15, 15*a*.

1854. 'Liasf. v. Göttingen,' t. iii. fig. 24.
1865. Brady, *loc. cit.* pl. i. fig. 11.
1858. Terquem, *loc. cit.* pl. i. fig. 14.
Syn. 1858. *Hexagona.* Terquem, *loc. cit.* pl. i. fig. 13.

Shell straight, compressed, more or less pointed, with two conspicuous ribs on each side, and intermediate ones less marked. Septa straight or slightly chevron-shaped, not very long.

None of the quoted authors' figures represent good typical forms of this species, which is most abundant and very characteristic of the Lias, and apparently peculiar to it.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar; *A. Bucklandi*, Redcar, Robin Hood's Bay; *A. oxynotus*, Market Weighton, Warter; *A. capricornus*, Saltburn; *A. annulatus*, Millington.

Lingulina striata, *Spec. nov.*

Pl. XVIII., figs. 16, 16*a*.

This departs very widely from the original description of the genus *Lingulina*, being very long and pointed; but it is closely

allied to *L. tenera*. Its ribs are very fine and irregular, and it puts on several curious shapes (as does *L. tenera*): and in some the ribs are so unequal as to show the passage to the last-named form. Fig. 16*a* represents a scarcely compressed form with regular ribs, which has a very different appearance to the most typical; but it may be matched by the first portions of some of the larger ones.

Geological position.—Zone of *A. planorbis*, Cliff (abundant).

Nodosaria radicula, *Linnæus.*

Pl. XVIII., fig. 17.

1758. 'Systema Naturæ,' ed. 10.
1865. Brady, *loc. cit.* pl. i. fig. 4.
1860. Jones and Parker. 'Quart. Jour. Geol. Soc.' vol. xvi. pl. xix. figs. 1-5.
Syn. 1862. *Nodosaria nitida, regularis, claviformis, Glandulina conica, Marginulina pupoides.* Terquem, *loc. cit.* pl. v. figs. 11, 12; pl. xix. fig. 17; pl. v. figs. 10, 20.

The simple, globular, nearl equal-sizedy chambers, with marked constrictions, forming this straight shell, admit of no variation requiring a separate name. No definite distinction can be drawn between the Liassic and recent specimens, and the species is continuous between these periods.

Geological position.—Zones of *A. planorbis*, Cliff; *A. Bucklandi*, Redcar; *A. armatus*, Warter.

Nodosaria raphanus, *Linnæus.*

Pl. XVIII., figs. 14, 14*a*.

1758. 'Systema Naturæ,' ed. 10.
1865. Brady in Moore's 'Mid. and Up. Lias,' pl. i. fig. 6.
1860. Jones and Parker. 'Quart. Journ. Geol. Soc.' vol. xvi. pl. xix. fig. 10.
Syn. 1858. *Simoniana, sexcostata, hortensis.* Terquem, *loc. cit.* pl. i. figs. 4, 5; pl. xix. fig. 13.

The ribbed *Nodosariæ* differ in the number of the ribs, and the shape and connection of the chambers. The latter have too numerous and indefinite variations to be usefully distinguished. We may therefore use three names only: *N. raphanus*, for those with few ribs; *N. raphanistrum*, for those with many; and *N. nitida*, for some that are altogether much more slender and have still finer ribs. There is no doubt that isolated specimens unite all these together; but it is nevertheless convenient to distinguish them, and to keep the term *Nodosaria* for straight forms only. These are absolutely identical with living forms.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, and *A. Bucklandi*, Redcar.

Nodosaria raphanistrum, *Linnæus.*

Pl. XVIII., figs. 18, 18*a*.

1758. 'Systema Naturæ,' ed. 10.
1865. Brady, *loc. cit.* pl. i. fig. 7.
Syn. 1860. *Badenensis* (pars), *lineolata*. Jones and Parker, *loc. cit.* pl. xix. figs. 9–11.
1858, 63. *Prima, metensis*. Terquem, *loc. cit.* pl. i. fig. 6; pl. vii. fig. 5.

The many-ribbed variety, fig. 18*a*, is intermediate.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* and *A. Bucklandi*, Redcar; *A. capricornus*, Saltburn; *A. annulatus*, Millington.

Note.—In Messrs. Jones, Parker, and Brady's Monograph of the Foraminifera of the Crag, in the Palæontographical Society's volume for 1866, the names of these two species seem to be mis-matched with reference to pl. I., figs. 4 and 8.

Nodosaria nitida, *D'Orbigny.*

Pl. XVII., fig. 19.

1826. 'Annales des Sciences Nat.' p. 254, No. 33.
1871. Parker, Jones, and Brady. 'Annals of Nat. Hist.' pl. ix. fig. 44.

The slender constricted variety.

Geological position.—Zones of *A. planorbis*, Cliff (5 exs.); *A. capricornus*, Saltburn (1 ex.).

Genus Dentalina.

[Section with oblique septa and smooth chambers.]

Dentalina communis, *D'Orbigny.*

Pl. XVIII., fig. 19.

1840. 'Mém. Soc. Géol. France,' vol. iv. pl. i. fig. 4.
1860. Jones and Parker, *loc. cit.* pl. xix. figs. 25, 26.
1865. Brady, *loc. cit.* pl. i. figs. 12, 13.
Syn. 1858. *Vetusta, torta*. Terquem, *loc. cit.* pl. i. figs. 4, 6.

The first chamber varies in shape, and some have so strong constrictions between the chambers as to look like curved *Nodosaria radicula*.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Millington, Redcar; *A. Bucklandi*, Redcar and Robin Hood's Bay; *A. capricornus*, Saltburn; *A. margaritatus*, Eskdale (bottom seam).

Dentalina Breoni, *Terquem.*

Pl. XVIII., fig. 20.

1863. 'Mém. sur Foram. du Lias,' pl. vii. fig. 16.

Chambers rapidly increasing, last very much the largest. The outlines of both sides are sigmoid by the bending up of

the first chamber. The shell is very rough, and has an arenaceous appearance, but is calcareous. Terquem's figure, though not well representing Yorkshire forms, has the peculiar aspect of this species, which is very abundant in, and appears characteristic of, the Lias, unless Kubler's *Vaginulina clava* or *elegans* ('For. Schweiz, Jura,' tab. I., figs. 7. 8) represents it.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar.

Dentalina oligostegia? *Reuss.*

Pl. XVIII., fig. 21.

1845. 'Verst. Böhm. Kreide,' tab. xiii. figs. 19, 20.

This form is very constant; it consists of three chambers, of a peculiar wasp-like form, the centre one generally the smallest, and the two outside ones pointed.

Reuss's figure bears sufficient resemblance to this to induce me to refer it to his species, though with some doubt.

Geological position.—Zones of *A. planorbis*, Cliff; *A. Bucklandi*, Redcar (3 exs.); *A. annulatus*, Millington (1 ex. with the chambers obscure, but pointed at both ends).

Dentalina planata, *Spec. nov.*

Pl. XVIII., p. 22.

The sides are nearly straight, and quite free from constrictions. It is produced to a curved sharp point beyond the chambers below, and is surmounted above by a truncated cone with the apex at the top. Septa oblique.

I can find no representation of this from other localities.

Geological position.—Zones of *A. planorbis*, Cliff; *A. annulatus*, Millington.

[Section with straight septa and smooth chambers.]

Dentalina pauperata, *D'Orbigny.*

Pl. XVIII., p. 23.

1846. 'Foram. Foss. de Vienne,' pl. i. figs. 57, 58.
1865. Brady, *loc. cit.* pl. i. fig. 14 (non Jones and Parker, *loc. cit.* pl. xix. fig. 22).
1867. Jones, Parker, and Brady. 'Crag Foram.' (Pal. Soc.) pl. i. figs. 13—18.
Syn. 1858, *Terquemi, obscura, subelegans, irregularis, Collenoti, arbuscula.*
1863 Terquem, *loc. cit.* pl. ii. figs. 1, 2; pl. v. figs. 21, 23; pl. vii. fig. 15; pl. xix. fig. 30.

No constrictions between the earlier chambers; apex pointed or globular; shell stout and large. This shell is usually called *D. pauperata*, but the name is not the earliest applied to it.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*,

Redcar (3 exs.); *A. Bucklandi*, Redcar (3 exs.); *A. annulatus*, Hob Hill (2 exs.)

Dentalina brevis, *D'Orbigny.*

Pl. XVIII., p. 24.

1846. 'For. Foss. de Vienne,' pl. ii. figs. 9. 10 (non Jones and Parker, *loc. cit.* pl. xix. figs. 23, 24. See Jones, Parker, and Brady, *loc. cit.* pl. iv. fig. 10).
Syn. 1862. *Perlucida, compressa.* Terquem, *loc. cit.* pl. v. fig. 22; pl. vii. fig. 10.

This differs from *D. pauperata* in the small number of chambers, and in their being more conspicuous. Its aspect is quite different, and the shell seems to have been thin, as they are sometimes compressed by pressure, as in *D. compressa* of Terquem.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* and *A. Bucklandi*, Redcar.

Dentalina tecta, *Terquem.*

Pl. XVIII., fig. 25.

1858. 'For. du Lias,' pl. ii. fig. 21.

Shell nearly straight; chambers cylindrical, with a tendency to compression, limbate.

Geological position.—Zone of *A. planorbis*, Cliff (4 exs.).

Dentalina nodosa, *D'Orbigny.*

Pl. XVIII., fig. 26.

1840. 'Mém. Soc. Géol. France,' pl. i. figs. 6, 7 (non *Nodosaria nodosa* (D'Orbigny) in Parker, Jones, and Brady, *loc. cit.* pl. ix. fig. 55).
Syn. 1858, 62. *Subnodosa* (non Reuss), *pyriformis, simplex.* Terquem, *loc. cit.* pl. ii. figs. 7, 22; pl. v. fig. 17.

A slender form, each chamber slightly pear-shaped, nearly straight.

Geological position.—Zone of *A. planorbis*, Cliff (3 exs.).

Dentalina monilis, *Cornuel.*

Pl. XVIII., fig. 27.

1848. 'Mém. Soc. Géol. France.' 2nd ser. vol. iii. fig. 18.
Syn, 1871. *Nodosaria filiformis* (D'Orbigny). Parker, Jones, and Brady, *loc. cit.* pl. ix. fig. 48.
1858. *D. vetustissima, baccata, fragilis, pseudomonile,* Terquem, *loc. cit.* pl. ii. figs. 8, 9, 17, 18.

Each chamber is egg-shaped, and they seem as if simply strung together. Shell much curved, slender. Chambers variable in size.

Geological position.—Zones of *A. planorbis*, Cliff; *A. annulatus*, Millington (1 ex.).

Dentalina glandulosa, *Terquem.*

Pl. XIX., fig. 2.

1862. 'Foram. Foss. du Lias,' pl. v. fig. 15.
Syn. 1865. *Filiformis* (D'Orbigny). Brady, *loc. cit.* pl. i. fig. 16.

Each chamber is very elongate, and is separated by a gradual constriction from the next.

D'Orbigny's name *filiformis* was given to a shell figured by Soldani, whose work is very inaccessible. Parker, Jones, and Brady (*loc. cit.*) figure *D. monilis* under this name. Brady (*loc. cit.*) figures a different form under the same; and Reuss applies the same name to a different species ('Böhm. Kreide,' vol. XII., fig. 28), so that to avoid confusion it is best to adopt a different one, such as Terquem's.

Geological position.—Zones of *A. planorbis*, Cliff (2 exs.); *A. angulatus*, Redcar (1 ex.); *A. Bucklandi*, Redcar (8 exs.).

Note.—In Pl. XVII., fig. 20, is represented what may be a Dentaline, such as Terquem describes as *Oolina pentagona*; but as no septa are visible, it may be an unknown curved spine. It is from the *annulatus*-beds at Millington.

[Section with ribbed chambers.]

Dentalina rapa, *D'Orbigny.*

Pl. XIX., fig. 3.

1826. 'Annal. des Sc. Nat.' p. 253.
1871. Parker, Jones, and Brady. 'Ann. Nat. Hist.' 4th ser. vol. viii. pl. ix. fig. 11 (non *obliqua*).

This may be described as a curved form of *Nodosaria raphanus* (not *raphanistrum*). Its chambers are exceptionally narrow, and little marked, looking as if they were separated by being tied up.

The name *obliqua* is rejected, because (1) there is a confusion between *Nodosaria* and *Dentalina* of that name; (2), many different forms have received this name from Williamson, Parker, Jones, and Brady. The figure of *D. rapa*, referred to above, represents a curved shell.

Geological position.—Zones of *A. angulatus*, Redcar (5 exs.); *A. armatus*, Warter.

Dentalina obliquestriata, *Reuss.*

Pl. XIX., fig. 4.

1851. 'Zeitsch. Deutsch. Geol. Ges.' vol. iii. pl. iii. figs. 11, 12.
1866. Parker, Jones, and Brady. 'Crag Foram' pl. i. fig. 19.
Syn. 1858. *Matutina, primæva, multicosta.* Terquem, *loc. cit.* pl. i. figs. 11, 12; pl. xix. fig. 32.

A fine-ribbed, many-chambered form, with the ribs running obliquely.

Geological position.—Zones of *A. angulatus*, Redcar; *A. Bucklandi*, Robin Hood's Bay.

Dentalina funiculosa, *Terquem*.

Pl. XVIII., fig. 28.

1866. 'Foram. Foss. du Lias,' pl. xix. fig. 29.

The chief character of this species, as pointed out by Terquem, is the constant bifurcation of the ribs. The Yorkshire forms are more pointed at the apex, and smaller in the middle. They are very distinct from *D. obliquestriata* or *D. rapa*.

Geological position.—Zones of *A. oxynotus*, Market Weighton, Warter; *A. capricornus*, Saltburn. This beautiful species is very abundant at the first-named locality.

Dentalina burgundiæ, *Terquem*.

Pl. XVIII., fig. 29.

1863. 'Foram. Foss. du Lias,' pl. ix. fig. 3.
Syn. 1866. *D. quadricosta*, *Marginulina impressa*, *M. rustica* (pars). Terquem, *loc. cit.* pl. v. fig. 16; pl. ix. figs. 2, 5*a*.

Small, curvature slight, ribs few, masking the division into chambers—a first step towards *Marginulina raphanus*.

Geological position.—Zones of *A. angulatus*, Redcar; *A. Bucklandi*, Redcar, Robin Hood's Bay; *A. oxynotus*, Warter (4 exs.); *A. annulatus*, Millington.

Dentalina nummulina, *Gümbel*.

Pl. XVIII., fig. 30.

1868. 'Foram. Fauna Nordalp. Eocän.' pl. i. fig. 45.

A small pointed shell, with fine striæ running parallel to its sides, which are nearly straight; chambers obscure.

This is an extremely fine-ribbed form of the *D. obliqua* of Parker, Jones, and Brady ('Crag Foram.,' pl. I., fig. 9), though differing in some respects. Gümbel's figure represents it exactly.

Geological position.—Zones of *A. capricornus*, Saltburn (5 exs.); *A. annulatus*, Millington (1 ex.).

Marginulina reversa, *Spec. nov.*

Pl. XVIII., fig. 31.

Very inflated, septa only indicated within; straight or often concave on the side of the aperture; the opposite side boldly convex; first chamber often swollen.

This species is remarkable for having the usual curvature of *Marginulina* reversed. Possibly Terquem's *M. Deslongchampsi*

(*loc. cit.* pl. VIII., fig. 8) belongs here; but the drawing is not sufficiently characteristic.

Geological position.—Zones of *A. Bucklandi*. Robin Hood's Bay; *A. capricornus*, Saltburn; *A. annulatus*, Hob Hill (1 ex.).

Marginulina raphanus, *Linnæus*.

Pl. XIX., fig. 5.

1758. 'Systema Naturæ,' ed. 10.
1826. D'Orbigny. 'Ann. des Sc. Nat.' vol. viii. pl. x. figs. 7, 8.
1865? Brady, *loc. cit.* pl. ii. fig. 21.
1867. Jones, Parker, and Brady. 'Crag. Foram.' pl. i. fig. 21.
Syn. 1854. *Orthocerina multicostata? Marginulina rugosa?* Bornemann. 'Liasf. v. Göttingen,' pl. iii. figs. 14, 26.
1858. *M. undulata, metensis, variabilis, radiata, D. fasciata.* Terquem, *loc. cit.* pl. iii. figs. 2, 3; pl. ix. figs. 6, 10; pl. xix. fig. 25.

Shell greatly curved, with acute, oblique ribs, festooned by the chambers. Section circular; first chamber often globular.

Bornemann's forms do not occur in Yorkshire, but they seem representatives of our shells.

Geological position.—Zones of *A. planorbis*, Cliff; *A. Bucklandi*, Robin Hood's Bay; *A. armatus*, Warter.

Marginulina picta, *Terquem*.

Pl. XIX., figs. 6, 6*a*, 6*b*.

1866. 'For. Foss. du Lias,' pl. xvii. fig. 12.
Syn. 1863. *Quadricosta.* Terquem, *loc. cit.* pl. viii. fig. 12.

This differs from the last by being flattened in section. It is a most variable shell, and the three figures represent very different appearances: yet the change is uniform and in some instances seems due to age, so that they must be all named as one. The shortest differs little from *Cristellaria costata* of D'Orbigny.

Geological position.—Zones of *A. planorbis*, Cliff (3 exs.); *A. angulatus* and *A. Bucklandi*, Redcar; *A. oxynotus*, Market Weighton and Warter.

Marginulina inæquistriata, *Terquem*.

Pl. XIX., fig. 7.

1863. 'For. Foss. du Lias,' pl. viii. fig. 15.
Syn. 1862. *Cristellaria articulata, C. Eugenii, C. Pickettyi, C. ligata.* Terquem, *loc. cit.* pl. vi. fig. 8; pl. ix. fig. 16; pl. xxi. fig. 31; pl. xxii. fig. 1.
1866. *Planularia Bronni* (Rom.). Brady. 'Mid. and Up. Lias,' pl. ii. fig. 30 (non Römer).

This differs from the last in having fine striæ, instead of ribs; they cover the whole side, and are sometimes straight and some-

times oblique and irregular. The shell varies in breadth. Terquem's figures best represent the general form, which is not that of a *Planularia*. (See remarks on that genus.)

Geological position.—Zones of *A. angulatus* and *A. Bucklandi*, Redcar.

Marginulina Römeri, *Reuss.*

Pl. XIX., figs. 8, 8*a*.

1845. 'Böhm. Kreide,' pl. viii. fig. 10.
Syn.? 1863. *Simplex?* Terquem, *loc. cit.* pl. viii. fig. 1.

This might equally well be called *Vaginulina*, as far as regards shape. It is a very narrow and delicate shell, in some (fig. 8*a*) produced to a point, and the sides nearly parallel. The chambers are oblique, narrow, more or less swollen.

Geological position.—Zone of *A. planorbis*, Cliff.

Marginulina depressa, *Spec. nov.*

Pl. XIX., fig. 9.

A near ally of *M. lituus* of D'Orbigny, which the more swollen and produced individuals greatly resemble. The type, however, is compressed, triangular in shape, very short, and with few oblique narrow chambers, with septa parallel to the base, the first chamber being very small and recurved.

Geological position.—Zones of *A. planorbis*, Cliff, and *A. Bucklandi*, Redcar (2 exs.).

Marginulina unicostata, *Terquem.*

Pl. XVII., fig. 21.

1858. 'For. Foss. du Lias,' pl. ii. fig. 19.

One side has a border to it. The chambers are moderately inflated and oblique.

Geological position.—Zone of *A. planorbis*, Cliff (2 exs.).

Marginulina? Pauliniæ, *Terquem.*

Pl. XVII., fig. 22.

1866. 'For. Foss. du Lias,' pl. xvii. fig. 5.

Elongated, fusiform, circular in section; first chamber pointed, the remainder oblique, becoming shorter and as it were twisted on the axis. A very peculiar form, rather like a *Bigenerina*. A similar specimen is figured by Terquem, as above.

Geological position.—Zone of *A. annulatus*, Hob Hill (1 ex.).

GENUS PLANULARIA.

This genus was established by Defrance for a straight-sided shell (*P. auris*), and as such was originally accepted by D'Orbigny. His subsequent union of it with *Cristellaria*, and the consequent ranging of some Cristellarians under this name, has created confusion. (See the remarks of Terquem in his 'Premier Mém. sur les Foram. du Système oolithique,' 1867, p. 48, &c.) He unites them to Marginulina as a particular section, while Jones and Parker ('Quart. Journ. Geol. Soc.' vol. xvi. pl. XX. figs. 30–36) place them with *Vaginulina;* but the characters of the genus are well marked. Its sides are flat or concave, its straight back is often bordered by ridges, it has a triangular shape and nearly rhomboid chambers, with a tendency to become spiral and to have its aperture on a produced neck.

Planularia arguta, *Reuss.*

Pl. XIX., fig. 10.

1860. 'Sitz. Ak. Wiss. Wien,' vol. xl. bd. 8, pl. viii. fig. 4.

Borders elevated, septa parallel at first, afterwards converging; no ornaments.

Geological position.—Zone of *A. Bucklandi*, Redcar (1 ex.).

Vaginulina legumen, *Linnæus.*

Pl. XIX., fig. 11.

1758. 'Systema Naturæ,' ed. 10.
1865. Brady, *loc. cit.* pl. i. fig. 18.
1860? Jones and Parker, *loc. cit.* pl. xix. figs. 27, 28.
Syn. 1845. *N. Hausmanni.* Bornemann, *loc. cit.* fig. 25.

Shell moderately broad, with oblique chambers, rather compressed.

Geological position.—Zone of *A. capricornus*, Saltburn (4 exs.).

Vaginulina anomala, *Spec. nov.*

Pl. XVII., figs. 23, 23*a*.

Very short, pyramidal; transverse section roundly triangular, sides nearly straight, last chamber large; septa obscure, oblique.

This resembles *Marg. depressa* in the arrangement of its chambers, but is triangular in section instead of compressed, and the first chamber is not curved.

Geological position.—Zone of *A. capricornus*, Saltburn (5 exs.).

Cristellaria pauperata, *Jones and Parker*.

Pl. XIX., fig. 12.

1860. (*Planularia.*) 'Quart. Journ. Geol. Soc.' vol. xvi. pl. xx. fig. 39.
1865. Brady, *loc. cit.* pl. ii. figs. 24, 25.
Syn. 1862. *Irregularis, simplex.* Terquem, *loc. cit.* pl. vi. fig. 2; pl. ix. fig. 15.
1854. *Varians* (pars). Bornemann, *loc. cit.* fig. 34, only.

The whole shell forms an irregular oval, with the septa marked as curved lines, becoming less curved and more oblique, but not forming a spiral.

Geological position.—Zones of *A. planorbis*, Cliff (3 exs.); *A. angulatus*, Redcar (2 exs.).

Cristellaria recta, *D'Orbigny*.

Pl. XIX., figs. 13, 13*a*; pl. XVII., fig. 24.

1839. 'Mém. Soc. Géol. France,' vol. iv. pl. i. figs. 8, 9.
Syn. 1865. *Marginula ensis* and *C. rhomboidea.* Brady, *loc. cit.* pl. ii. fig. 23; pl. iii. fig. 40.
1845. *C. protracta.* Bornemann, *loc. cit.* fig. 27.
1862, 1866. *C. Terquemi, obscura, nucleata, normaniæ, amœna, vicinalis, ventricosa.* Terquem, *loc. cit.* pl. iii. fig. 18; pl. vi. fig. 4; pl. ix. figs. 19, 21; pl. xviii. figs. 7, 8; pl. xxii. fig. 4.

Spiral portion small. The rest of the chambers in a linear series, much larger than the spiral portion, and comparatively narrow chambers, increasing or decreasing in size. Inner side either round or showing a somewhat flat area.

The relationship of this species is plainly with *Cristellariæ*, rather than with *Marginulinæ*. The Saltburn specimens (fig. 24) are covered with a shelly deposit, which completely masks the spiral portion, and gives the appearance of *Vaginulina legumen*.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Millington; *A. Bucklandi*, Redcar (2 exs.); *A. oxynotus*, Market Weighton; *A. capricornus*, Saltburn.

Cristellaria major, *Bornemann*.

Pl. XIX., fig. 15.

1854. 'Liasf. v. Göttingen,' pl. iv. fig. 31.
Syn. 1865. *Longa?* Brady, *loc. cit.* pl. ii. fig. 27 (non Cornuel).
186–. *Ligata.* Terquem, *loc. cit.* pl. xxii. fig. 1.

Spiral portion small; rectilinear broad; chambers numerous; septa not converging towards the spiral; shell compressed.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar (3 exs.); *A. Bucklandi*, Redcar (4 exs.); *A. oxynotus*, Market Weighton (2 exs.); *A. armatus*, Warter.

Cristellaria crepidula, *Fichtel and Moll.*

Pl. XIX., fig. 14; pl. XVII., fig. 25.

1803. 'Testacea Microscopica,' pl. xix. figs. *g, h, i.*
1865. Brady, *loc. cit.* pl. iii. fig. 39.
Syn. 1863. *Cordiformis, acuminata.* Terquem, *loc. cit.* pl. ix. fig. 14; pl. x. fig. 5.

Under this name must be ranged a considerable variety of forms which pass into each other, but all have the later chambers converging more or less towards the spiral part, both sides of the shell being uniformly convex. Their length varies, the shorter ones (fig. 14) being exactly represented by *C. truncata* of Reuss (Kreide Lemberg, pl. III., figs. 8, 9).

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* (2 exs.), and *A. Bucklandi*, Redcar; *A. capricornus*, Saltburn; *A. annulatus*, Millington (8 exs.) and Hob Hill (1 ex.).

Cristellaria Bronnii, *Römer.*

Pl. XVII., fig. 26.

1841. (*Planularia.*) 'Norddeutsch. Kreide,' tab. xv. fig. 14.
1860. Jones and Parker, *loc. cit.* pl. xx. fig. 40 (non Brady, *loc. cit.* fig. 30).

This is the central form, from which all the others diverge in one direction or the other. Its spiral portion is tolerably large, the straight part moderately long and broad, and the septa incline partially to the spiral part. It is moderately inflated in section, but not so flat as *C. major.*

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar, Millington; *A. Bucklandi*, Redcar, Robin Hood's Bay; *A. oxynotus*, Market Weighton, Warter; *A. capricornus*, Saltburn; *A. annulatus*, Millington.

Cristellaria varians, *Bornemann.*

Pl. XVII., fig. 27; pl. XIX., fig. 16.

1854. 'Lias. v. Göttingen,' pl. iv. figs. 32, 33.
Syn. 1854. *Minuta, convoluta.* Bornemann, *loc. cit.* figs. 37, 38.
1865. ? *C. acutauricularis.* Brady, *loc. cit.* pl. iii. fig. 38.

The later chambers all abut upon the spiral portion, and become nearly vertical, so that the whole shell has a semicircular outline. When the chambers are swollen, it approaches the *C. acutauricularis* of Fichtel and Moll, but is never so inflated. This is the most compact of the series.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* (2 exs.), and *A. Bucklandi*, Redcar; *A. oxynotus*, Market Weighton, Warter; *A. capricornus*, Saltburn; *A. annulatus*, Millington.

Cristellaria globifera, *Spec. nov.*

Pl. XIX., fig. 17.

The first chamber is a conspicuous sphere, standing out on one side almost separate from the rest. The other chambers are feebly marked. The outside is very convex; the inside very swollen in outline, and also transversely, as in *C. acutauricularis.*

Geological position.—Zones of *A. planorbis*, Cliff; *A. Bucklandi*, Robin Hood's Bay (1 ex.); *A. annulatus*, Millington (1 ex.).

Cristellaria rotulata, *Lamarck.*

Pl. XIX., fig. 18.

1801. 'Anim. sans Vertèbres.'
1858. Parker and Jones, *loc. cit.* pl. xx. figs. 42, 48.
1865. Brady, *loc. cit.* fig. 36.
Syn. 1854. *Robulina Gottingensis, R. nautiloides.* Bornemann, *loc. cit.* figs. 40, 42.
1862. *Cr. rustica, Cr. liasina, Robulina liasina.* Terquem, *loc. cit.* pl. iii. fig. 19; pl. vi. figs. 6, 9.

This is the type of an entirely distinct section of Cristellaria, which might well demand a distinct generic name. Its growth is entirely spiral, round a central sphere; the septa are only marked within; the aperture is on a prominence, situated not quite on the outside of the chamber. The margin is angular, or nearly keeled.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar (3 exs.); *A. Bucklandi*, Robin Hood's Bay (1 ex.); *A. oxynotus*, Market Weighton (2 exs.); *A. capricornus*, Saltburn.

Flabellina rugosa, *D'Orbigny.*

Pl. XIX., fig. 19.

1839. 'Mém. Soc. Géol. France,' vol. iv. pl. ii. figs. 4–7.
1865. Brady, *loc. cit.* pl. iii. figs. 44–46.
Syn. 1863. *Inæquilateralis.* Terquem, *loc. cit.* pl. x. fig. 16.

This differs only from *Cristellaria Bronnii* by having its last chamber Λ-shaped. Had not the species been recorded elsewhere, the Yorkshire specimens would not have been sufficiently numerous to prove them to be any more than abnormal growths of the Cristellarian named.

Geological position.—Zones of *A. planorbis*, Cliff (2 exs.); *A. Bucklandi*, Robin Hood's Bay (1 ex.).

Frondicularia complanata, *Defrance.*

Pl. XIX., fig. 20.

1825. 'Dict. des Sc. Nat.' vol. 35.
1866. Brady, *loc. cit.* pl. iii. fig. 47.

Only a few small examples occur; but they exactly resemble the first few chambers of the larger shells figured by Brady as above, it is very probable that they are stinted forms.

They consist of a central spherical or ellipsoidal chamber and two or three Λ-shaped ones with the lower portions turned in, so as to partially embrace the first.

Geological position.—Zones of *A. planorbis*, Cliff (3 exs.); *A. angulatus*, Redcar (1 ex.).

Frondicularia lignaria? *Terquem.*

Pl. XVII., fig. 28.

1866. 'Mém. sur For. du Lias,' pl. xix. fig. 14.

Shell compressed, rhomboidal, more than half as broad as high, with chambers having acute angles, the surface covered with fine, longitudinal, discontinuous striæ.

Terquem describes his shell as smooth, but it agrees so well with this in other respects, that the difference may be due to preservation.

Geological position.—Zone of *A. capricornus*, Saltburn (4 exs.).

Frondicularia intumescens, *Bornemann.*

Pl. XIX., fig. 21.

1854. 'Liasf. v. Göttingen,' pl. iii. fig. 19.
Syn. 1854. *Major.* Bornemann, *loc. cit.* fig. 20.
1858, 66. *Nitida, sacculus.* Terquem, *loc. cit.* pl. i. fig. 9; pl. xix. fig. 20.

Shell spatulate; first chamber inflated, curves on both sides, gently convex; swollen along the median line; apertural margin obtuse; no ornaments.

Geological position.—Zones of *A. angulatus* and *Bucklandi*, Redcar.

Frondicularia Terquemi, *D'Orbigny.*

Pl. XIX., fig. 22.

1858. In Terquem, *loc. cit.* pl. i. fig. 12.
Syn. 1858. *Bicostata.* D'Orbigny in Terquem, *loc. cit.* pl. i. fig. 11.

This differs from the last in having straighter sides, sharper apex, and its aperture on a produced neck, and a depression

down the central line instead of a thickening. It is also often, but not always, provided with ribs more or less prominent and scattered.

This form leads us on to the cretaceous *F. trisulca* of Reuss, which the more delicate forms much resemble. It is intermediate between the last and next.

Geological position.—Zones of *A. Bucklandi*, Robin Hood's Bay (1 ex.).; *A. capricornus*, Saltburn.

Frondicularia sulcata, *Bornemann.*

Pl. XIX., fig. 23.

1854. 'Liasform. v. Göttingen,' pl. iii. fig. 22.
Syn. 1854. *Dubia.* Bornemann, *loc. cit.* fig. 23.
1866. *Striatula* (Reuss). Brady, *loc. cit.* pl. iii. fig. 46.
1858, 62. *Pulchra, multicostata.* Terquem, *loc. cit.* pl. i. fig. 10; pl. v. fig. 14.

Shape an elongated triangle, like the last, surmounted with another more obtuse triangle. Covered with fine longitudinal ribs.

The cretaceous *Fr. striatula* of Reuss, under which Brady cites this species, is less acute, and the ribs are not so strong—distinctions which, to my mind, render the Liassic form worthy of a separate name.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* and *A. Bucklandi*, Redcar.

Frondicularia nodosaria, *Terquem.*

Pl. XIX., fig. 24; pl. XVII., fig. 44.

1866. 'Mém. sur Foram. du Lias,' pl. xxii. figs. 25–30.
Syn. 1860. *Striatula.* Jones and Parker, *loc. cit.* pl. xix. fig. 17.

Chambers separate, of rounded outline, with longitudinal striæ; the whole long and narrow. The striæ are not properly shown in pl. XIX., fig. 24, and the other figure is an extreme form possibly belonging to the same, which has much the appearance of a *Textularia* from a depression down the centre.

Geological position.—Zones of *A. planorbis* (2 exs.); *A. angulatus*, Redcar (3 exs.).

Othocerina hæringense, *Gümbel.*

Pl. XVII. figs. 29, 29*a*.

1868. 'Foram. Eocän.' pl. i. fig. 55.

Shell an equilateral 3-sided pyramid, with curving edges; base inflated, aperture on a neck in the centre; septa curved with the base; marked by circular arcs on the sides; edges ele-

Polymorphina nodosaria, *Reuss*.

Pl. XVII., fig. 34.

1863. 'Sitz. Akad. Wissen.' vol. xlviii. pl. vii. fig. 85.
1870. Brady, Parker, and Jones, *loc. cit.* pl. xl. fig. 18.
1867. Jones, Parker, and Brady. 'Crag Foram.' pl. i. figs. 55–58.
Syn. 1863. *Quadrata, pupiformis* (pars). Terquem, *loc. cit.* pl. xii. figs. 25–32; pl. xiii. figs. 27–30.

Chambers nearly in a linear series, except the first two; each reaches across the shell, but is much narrower on one side than on the other.

Geological position.—Zone of *A. Bucklandi*, Redcar (2 exs.).

Polymorphina simplex, *Terquem*.

1863. *Loc. cit.* pl. 11. figs. 1–4.
Syn. 1863. *Agglutinans*. Terquem, *loc. cit.* pl. xi. figs. 5, 8.

These are rough and arenaceous-looking, and narrower than most of the *P. fusiformes*. [The figure has been accidentally omitted.]

Geological position.—Zone of *A. planorbis*, Cliff.

Polymorphina distincta, *Terquem*.

Pl. XVII., fig. 35.

1866. 'Mém. sur Foram. du Lias,' pl. xxii. fig. 32.

This is elongated, with many chambers, like *P. compressa;* but the last are much larger than the earlier ones, occupying the whole breadth, and overhanging the others. It is sharply pointed.

Terquem's figure represents an extreme variety. The species seems quite a distinct one.

Geological position.—Zone of *A. planorbis*, Cliff.

Polymorphina burdigalensis, *D'Orbigny*.

Pl. XVII., fig. 36.

1826. 'Ann. Sc. Nat.' vol. vii. p. 265.
1870. Brady, Parker, and Jones, *loc. cit.* pl. xxxix. fig. 9.

Shell compressed, last two chambers overlapping the greater part of the earlier ones, separating in a median line.

Geological position.—Zone of *A. annulatus*, Hob Hill.

vated with longitudinal costæ. Height less than 3 times the breadth of one side.

This very distinct form is not *Vaginulina tricarinata*, as it has a central aperture. The only figure I can find is that quoted.

Geological position.—Zone of *A. capricornus*, Saltburn.

Othocerina rhomboidalis, *Spec. nov.*

Pl. XVII., figs. 30, 30*a*.

Similar to the last, but four-sided, and the sides not inflated; edges elevated. Of the four examples known, two are square and shorter, the other two rhomboidal, and of greater length.

Geological position.—Zone of *A. capricornus*, Saltburn (4 exs.).

Polymorphina fusiformis, *Römer.*

Pl. XVII., fig. 31.

1838. 'Neues Jahrb. für Min.' pl. iii. fig. 37.
1870. Brady, Parker, and Jones. 'Mon. of Polymorphina. Trans. Linnean Soc.' vol. xxvii. pl. xxxix. fig. 5.
Syn. 1846. *Liassica.* Strickland. 'Quart. Jour. Geol. Soc.' vol. ii. p. 30.
1866. *Lactea.* Brady, *loc. cit.* pl. iii. fig. 49.
1863. *Bilocularis* (pars), *ovula, Breoni, cruciata* (pars). Terquem, *loc. cit.* pl. xi. figs. 11, 12; figs. 33–44; figs. 1–6; figs. 1–8.

Chambers few; shell uniformly convex on both sides, or nearly so, pointed at both ends.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus*, Redcar; *A. capricornus*, Saltburn; *A. annulatus*, Hob Hill.

Polymorphina compressa, *D'Orbigny.*

Pl. XVII., fig. 32.

1846. 'For. Foss. de Vienne,' pl. xii. figs. 32–34.
1870. Brady, Parker, and Jones. 'Mon. Polymorphina,' pl. xl. fig. 12.
1866. Brady, *loc. cit.* pl. iii. fig. 50.
Syn. 1863. *Angustata, pyriformis, sinuata.* Terquem, *loc. cit.* pl. xii. figs. 33–35; figs. 41–43; fig. 48.

Chambers more numerous, arranged as it were in two linear series, none reaching across the shell; pointed at both ends.

Geological position.—Zone of *A. planorbis*, Cliff.

Polymorphina problema, *D'Orbigny.*

Pl. XVII., fig. 33.

1826. 'Ann. Sc. Nat.' vol. vii. p. 266.
1870. Brady, Parker, and Jones, *loc. cit.* pl. xxxix. fig. 11.
1866. Parker, Jones, and Brady. 'Crag Foram.' pl. i. fig. 64.

Chambers pretty numerous, earlier ones smaller, but all hanging as it were in a cluster, and all distinct.

Geological position.—Zone of *A. planorbis*, Cliff.

Polymorphina nodosaria, *Reuss.*

Pl. XVII., fig. 34.

1863. 'Sitz. Akad. Wissen.' vol. xlviii. pl. vii. fig. 85.
1870. Brady, Parker, and Jones, *loc. cit.* pl. xl. fig. 18.
1867. Jones, Parker, and Brady. 'Crag Foram.' pl. i. figs. 55–58.
Syn. 1863. *Quadrata, pupiformis* (pars). Terquem, *loc. cit.* pl. xii. figs. 25–32; pl. xiii. figs. 27–30.

Chambers nearly in a linear series, except the first two; each reaches across the shell, but is much narrower on one side than on the other.

Geological position.—Zone of *A. Bucklandi*, Redcar (2 exs.).

Polymorphina simplex, *Terquem.*

1863. *Loc. cit.* pl. 11. figs. 1–4.
Syn. 1863. *Agglutinans.* Terquem, *loc. cit.* pl. xi. figs. 5, 8.

These are rough and arenaceous-looking, and narrower than most of the *P. fusiformes.* [The figure has been accidentally omitted.]

Geological position.—Zone of *A. planorbis*, Cliff.

Polymorphina distincta, *Terquem.*

Pl. XVII., fig. 35.

1866. 'Mém. sur Foram. du Lias,' pl. xxii. fig. 32.

This is elongated, with many chambers, like *P. compressa;* but the last are much larger than the earlier ones, occupying the whole breadth, and overhanging the others. It is sharply pointed.

Terquem's figure represents an extreme variety. The species seems quite a distinct one.

Geological position.—Zone of *A. planorbis*, Cliff.

Polymorphina burdigalensis, *D'Orbigny.*

Pl. XVII., fig. 36.

1826. 'Ann. Sc. Nat.' vol. vii. p. 265.
1870. Brady, Parker, and Jones, *loc. cit.* pl. xxxix. fig. 9.

Shell compressed, last two chambers overlapping the greater part of the earlier ones, separating in a median line.

Geological position.—Zone of *A. annulatus*, Hob Hill.

Orbulina universa, *D'Orbigny.*

Pl. XVIII., fig. 32.

1839. 'Foram. de Cuba,' pl. i. fig. 1, and 'For. Foss. de Vienne,' pl. i. fig. 1.
Syn. 1862. *Punctata.* Terquem, *loc. cit.* pl. v. fig. 5.

A simple, minute, foraminiferous sphere, with a minute aperture on one side.

It may be doubted if these are not the first chambers of other forms. Their minuteness has mostly caused them to escape attention as fossils.

Geological position.—Zone of *A. Bucklandi*, Robin Hood's Bay.

Textularia agglutinans, *D'Orbigny.*

Pl. XVII., fig. 37.

1839. 'Foram. de Cuba,' pl. i. figs. 17, 18.
Syn. 1857. *Variabilis.* Williamson. 'Rec. Forams. of Great Britain,' figs. 162, 163.

Shell elongate, triangular; section nearly rectangular; chambers as broad as high, reaching about half-way across.

I can see nothing to distinguish this from D'Orbigny's species, which is also oblong in section.

Geological position.—Zones of *A. Bucklandi*, Redcar (1 ex.); *A. annulatus*, Millington, Hob Hill (2 exs.).

Pulvinulina elegans, *D'Orbigny.*

Pl. XVII., figs. 38, 38*a*.

1826. (*Rosalia.*) 'Ann. Sc. Nat.' vol. vii. p. 276.
1871. Parker, Jones, and Brady. 'Ann. Nat. Hist.' pl. xii. fig. 142.
1860. Jones and Parker. 'Quart. Jour. Geol. Soc.' vol. xvi. pl. xx. fig. 46.

Shell trochoid, with slanting septa on the upper surface, which is only moderately elevated. In the cast the earlier chambers are more separate than the later, appearing on both sides like little knobs; umbilicus filled up. The casts from Hob Hill (fig. 38*a*) show the chambers best; those from Redcar (fig. 38), the exterior.

Geological position.—Zones of *A. planorbis*, Cliff; *A. angulatus* and *A. Bucklandi*, Redcar; *A. annulatus*, Hob Hill and Millington.

Two specimens, one of which is figured in pl. XVII., fig. 39, which occurred in the washed-down shale from Redcar, might

be added to this list, but for a doubt as to their origin. They are *Nonionina cf. elegans* (Williamson), and *Polystomella striato-punctata*, two very well-known recent British forms. Every care was taken to obtain portions of the scars to which the sea had no access, and to be sure that there was no extraneous matter. Still the bare possibility of their having been forced into some unseen cranny, prevents me from recording what would be remarkable additions to the Liassic Microzoa. Nevertheless Terquem has found a Liassic Polystomella *inland*.

PLANTÆ.

BY RALPH TATE.

CLASS CRYPTOGAMIA.

Two casts of algæ are very common in the ironstone-beds on the coast, and seem to offer characters sufficiently distinct to justify the imposition of specific names.

Nulliporites furcillatus, *Spec. nov.*

Pl. XIV., fig. 7.

Frond cylindrical, slender, forking at regular distances.

Geological position.—Zone of *A. spinatus*, Staithes, Kettleness.

Chordophyllites cicatricosus, *Spec. nov.*

Pl. XIV., fig. 9.

Frond cylindrical, stout, simple, and of great length, and marked by rhomboidal depressions.

Length unknown, but exceeding 4 feet, thickness half an inch. This petrification is alluded to by Young and Bird as 'bearing a striking resemblance to the stalks of the common tangle,' &c.

Geological position.—The upper surface of the top block of ironstone at Old Nab, Staithes, is densely crowded with casts of this fucoid, overlapping and intertwining one among the other; it occurs also in the same bed at Kettleness.

Equisetites, *Sp.* (*? liassicus*, Heer).

A much worn internode from the *Bucklandi*-beds at Marske.

Alethopteris, *Sp.*

A fragment of a pinnule with sori, from the *angulatus*-beds at Givendale.

CLASS PHANEROGAMIA—ORDER CONIFERÆ.

Fossil wood is found in abundance in most of the Liassic strata on the coast, and in a variety of forms. We do not often meet with trunks of large size, most of the wood being found in fragments. Young and Bird state that round trunks of trees, 12 feet long and upwards, and a foot or more in diameter, have occasionally been discovered at Whitby, at Sandsend, Rockcliff, and other places. We have already recorded the occurrence of larger stems in the ironstone at Staithes and Eston. Generally the wood is compressed, and more or less like jet; but in the *capricornus* and *spinatus* beds cylindrical pieces of brown colour displaying concentric zones, visible to the unaided eye, are not at all rare. The exogenous structure is obvious. Phillips seems to have considered it to be coniferous. However, the publication of the evidence was left to Witham, who represented portions of thin slices of Liassic wood, from the neighbourhood of Whitby, as viewed by transmitted light, and referred the several specimens to the Coniferæ, distinguishing two separate arrangements of vessels on which were founded the species.

Peuce Huttoniana, *Witham.*

1831. 'Foss. Veg.' t. xiv. fig. 9; t. xv. figs. 4, 5.

Geological position.—Upper Lias, Whitby.

Peuce Lindleyana, *Witham.*

1831. 'Foss. Veg.' t. ix. figs. 1–5; t. xv. figs. 1–3.

Geological position.—Upper Lias, Whitby.

Another conifer, belonging to the Family Abietinæ, is known in the Yorkshire Lias, by its foliage, it is—

Pachyphyllum peregrinum, *Sternberg* (*Araucarites*).

See Lindley and Hutton, 'Foss. Flora.' t. lxxxviii.

Geological position.—Zone of *A. serpentinus*, Saltwick (Whitby Mus.).

INDEX OF SYNONYMS.

In this list we give those names that have been applied by previous authors to Fossils from the Yorkshire Lias which we have not adopted.

VERTEBRATA.

Synonyms.	Adopted Names.
Ichthyosaurus platyodon (*Phillips*).*	I. crassimanus, *Blake*.
Plesiosaurus macrocephalus (*Bailey and Carte*).	P. Simpsoni, *Blake*.

CEPHALOPODA.

Ammonites acuticarinatus, *Simpson*.	Arietites Bodleyi, *Buckman*.
——— æqualis, *Simpson*.	Ægoceras angulatus, *Schlotheim*.
——— alternatus, *Simpson*.	Harpoceras serpentinum, *Reinecke*.
——— ambiguus, *Simpson*.	Phylloceras Loscombi, *Sowerby*.
——— Andersoni, *Simpson*.	Stephanoceras Desplacei, *D'Orbigny*.
——— Andreæ, *Simpson*.	——— crassum, *Young and Bird*.
——— anguliferus, *Phillips*.	Ægoceras defossum, *Simpson*.
——— annuliferus, *Simpson*.	Stephanoceras crassum, *Young and Bird*.
——— antiquatus, *Simpson*.	Ægoceras Charmassei, *D'Orbigny*.
——— arcigerens, *Phillips*.	——— capricornum, *Schlotheim*.
——— arctus, *Simpson*.	Phylloceras Loscombi, *Sowerby*.
——— armatus (*Young and Bird*).	Stephanoceras fibulatum, *Sowerby*.
——— armiger, *Simpson*.	Ægoceras armatum, *Sowerby*.
——— athleticus, *Simpson*.	Stephanoceras commune, *Sowerby*.
——— attenuatus, *Simpson*.	——— annulatum, *Sowerby*.
——— aureolus, *Simpson*.	Arietites tardecrescens, *Hauer*.
——— aureus, *Simpson*.	Ægoceras brevispinum, *Sowerby*.
——— balteatus, *Phillips*.	Lytoceras cornucopia, *Young and Bird*.
——— Belcheri, *Simpson*.	Ægoceras Johnstoni, *Sowerby*.
——— Birdi, *Simpson*.	Amaltheus spinatus, *Bruguière*.
——— bispicatus, *Simpson*.	Ægoceras Birchii, *Sowerby*.
——— Boulbiensis, *Simpson*.	? Harpoceras subconcavum, *Young and Bird*.
——— Buckii, *Simpson*.	Amaltheus oxynotus, *Quenstedt*.
——— Bucklandi (*Simpson*).	Arietites Turneri, ——— stellaris, } *Sowerby*.
——— cereus, *Simpson*.	Ægoceras gagateum, *Young and Bird*.
——— clevelandicus *Young and Bird*.	Amaltheus margaritatus, *Montfort*.
——— complanatus (*Young and Bird*).	——— ferrugineus, *Simpson*.
——— complanatus (*Simpson*).	——— Oppeli, *Schlönbach*.
——— conjunctivus, *Simpson*.	——— ferrugineus, *Simpson*.

* Authors' names in brackets indicate that they have so called the species but have not originated the name.

SYNONYMS.	ADOPTED NAMES.
Ammonites convolutus, *Simpson.*	Ægoceras planicosta, *Sowerby.*
——— Conybeari (*Simpson*).	Arietites tardecrescens, *Hauer.*
——— cornucopia, *Simpson.*	Lytoceras fimbriatum, *Sowerby.*
——— cornuoides, *Brown.*	Arietites obtusus, *Sowerby.*
——— cornutus, *Simpson.*	Ægoceras Taylori, *Sowerby.*
——— crassibundus, *Simpson.*	Stephanoceras crassum, *Young and Bird.*
——— crassifactus, *Simpson.*	——— Desplacei, *D'Orbigny.*
——— crassiusculosus, *Simpson.* ——— crassiusculus, *Simpson.*	——— crassum, *Young and Bird.*
——— crassoides, *Simpson.*	——— Desplacei, *D'Orbigny.*
——— crassulosus, *Simpson.*	——— crassum, *Young and Bird.*
——— crassulus, *Simpson.*	——— Desplacei, *D'Orbigny.*
——— crenularis (*Simpson*).	Ægoceras Charmassei, *D'Orbigny.*
——— Crosbeyi, *Simpson.*	Stephanoceras Desplacei, *D'Orbigny.*
——— decussatus, *Simpson.*	Ægoceras aculeatum, *Simpson.*
——— dejectus, *Simpson.*	Amaltheus oxynotus, *Quenstedt.*
——— denotatus, *Simpson.*	Arietites Collenoti, *D'Orbigny.*
——— Dennyi, *Simpson.*	Phylloceras Loscombi, *Sowerby.*
——— depressus, *Simpson.*	Amaltheus margaritatus, *Montfort.*
——— easingtonensis, *Simpson.*	Phylloceras heterophyllum, *Sowerby.*
——— elegans, *Young and Bird.*	Harpoceras concavum, *Sowerby.*
——— elegantulus, *Simpson.*	——— exaratum, *Young and Bird.*
——— erugatus, *Young and Bird.*	Ægoceras planorbe, *Sowerby.*
——— exaratus (*Phillips*).	Harpoceras lythense, *Young and Bird.*
——— exasciatus, *Simpson.*	Amaltheus spinatus, *Bruguière.*
——— exortus, *Simpson.*	Ægoceras raricostatum, *Zieten.*
——— fabalis, *Simpson.*	Harpoceras comense, *Von Buch.*
——— fabricatus, *Simpson.*	——— spec. indet.
——— falcifer (*Phillips*).	——— elegans, *Sowerby.*
——— fasciatus, *Simpson.*	Lytoceras cornucopia, *Young and Bird.*
——— figulinus, *Simpson.*	Ægoceras capricornum, *Schlotheim.*
——— fimbriatus (*Simpson*).	Lytoceras cornucopia, *Young and Bird.*
——— flavus, *Simpson.*	Amaltheus Simpsoni, *Simpson.*
——— foveatus, *Simpson.*	Stephanoceras fonticulum, *Simpson.*
——— geometricus, *Phillips.*	Amaltheus solitarius, *Simpson.*
——— gubernator, *Simpson.*	Lytoceras jurense, *Zieten.*
——— Hamiltoni, *Simpson.* ——— hastatus, *Young and Bird.*	Ægoceras armatum, *Sowerby.*
——— Hawskerensis, *Simpson.*	Amaltheus spinatus, *Bruguière.*
——— heptangularis, *Young and Bird.*	Ægoceras striatum, *Reinecke.*
——— heterogeneus, *Young and Bird.*	——— Henleyi, *Sowerby.*
——— hildensis, *Young and Bird.*	Harpoceras bifrons, *Bruguière.*
——— ignotus, *Simpson.*	Ægoceras Regnardi, *D'Orbigny.*
——— illatus, *Simpson.*	? ——— gagateum, *Young and Bird.*
——— incrassatus, *Simpson.*	Stephanoceras crassum, *D'Orbigny.*
——— integricostatus, *Simpson.*	Ægoceras gagateum, *Young and Bird.*
——— intertextus, *Simpson.*	Non-liassic (not = Ag. Charmassei, as stated at p. 272).
——— involutus, *Simpson.*	Ægoceras sociale, *Simpson.*
——— Jamesoni (pars), *Simpson.*	——— sagittarium, *Blake.*
——— lens, *Simpson.*	Amaltheus lynx, *D'Orbigny.*
——— lenticularis, *Young and Bird.*	——— Engelhardti, *D'Orbigny.*
——— leptophyllus, *Simpson.*	Harpoceras lythense, *Young and Bird.*
——— limatus, *Simpson.*	Amaltheus Simpsoni, *Simpson.*
——— luridus, *Simpson.* ——— maculatus, *Young and Bird.*	Ægoceras capricornum, *Schlotheim.*

SYNONYMS.	ADOPTED NAMES.
Ammonites mammillatus, *Simpson*.	Ægoceras planicosta, *Sowerby*.
——— Marshallani, *Simpson*.	——— aculeatum, *Simpson*.
——— miles, *Simpson*.	——— armatum, *Sowerby*.
——— mulgravius, *Young and Bird*.	Harpoceras elegans, *Sowerby*.
——— mulgravius (*Simpson*), (pars).	——— elegans, *Sowerby*.
——— multanfractus, *Simpson*.	Arietites semicostatus, *Young and Bird*.
——— multifoliatus, *Simpson*.	? Harpoceras lythense, *Young and Bird*.
——— mutatus, *Simpson*.	? Ægoceras aculeatum, *Simpson*.
——— nanus, *Simpson*.	Phylloceras Loscombi, *Sowerby*.
——— nativus, *Simpson*.	Ægoceras validum, *Simpson*.
——— neglectus, *Simpson*.	Ægoceras gagateum, *Young and Bird*.
——— nitescens, *Young and Bird*.	Harpoceras algovianum, *Oppel*.
——— nitidus, *Young and Bird*.	Lytoceras cornucopia, *Young and Bird*.
——— nodulosus, *Young and Bird*.	Amaltheus margaritatus, *Montfort*.
——— obliquatus, *Young and Bird*.	Harpoceras Beanii, *Simpson*.
——— omissus, *Simpson*.	Ægoceras defossum, *Simpson*.
——— ovatulus, *Simpson*.	Harpoceras aalense, *Zieten*.
——— ovatus, *Young and Bird*.	——— primordiale, *Schlotheim*.
——— ovatus (*Phillips*).	——— cæcilia, *Reinecke*.
——— Owenensis, *Simpson*.	Ægoceras armatum, *Sowerby*.
——— peregrinus, *Simpson*.	Arietites scipionanus, *D'Orbigny*.
——— personatus, *Simpson*.	Arietites scipionanus, *D'Orbigny*.
——— Phillipsii, *Simpson*.	Harpoceras insigne, *Zieten*.
——— pinguis, *Simpson*.	——— comense, *Von Buch*.
——— polyphyllus, *Simpson*.	Amaltheus oxynotus, *Quenstedt*.
——— puteolus, *Simpson*.	Stephanoceras crassum, *Young and Bird*.
——— quadricornutus, *Simpson*.	Ægoceras Taylori, *Sowerby*.
——— radiatus, *Simpson*.	Arietites impendens, *Young and Bird*.
——— redcarensis, *Young and Bird*.	Ægoceras angulatum, *Schlotheim*.
——— regularis, *Simpson*.	Not Liassic.
——— resupinatus, *Simpson*.	Arietites Sauzeanus, *D'Orbigny*.
——— retentus, *Simpson*.	? Amaltheus Huntoni, *Simpson*.
——— reticularis, *Simpson*.	——— ? Engelhardti, *D'Orbigny*.
——— retusus, *Simpson*.	Ægoceras aculeatum, *Simpson*.
——— Ripleyi, *Simpson*.	Amaltheus trivialis, *Simpson*.
——— Robinsoni, *Simpson*.	——— oxynotus, *Quenstedt*.
——— rugatulus, *Simpson*.	Harpoceras aalense, *Zieten*.
——— rutilans, *Simpson*.	Amaltheus trivialis, *Simpson*.
——— semiarmatus, *Simpson*.	Stephanoceras subarmatum, *Young and Bird*.
——— sigmifer, *Phillips*.	Harpoceras aalense, *Zieten*.
——— simplex, *Simpson*.	Amaltheus Huntoni, *Simpson*.
——— siphuncularis, *Simpson*.	Ægoceras planicosta, *Sowerby*.
——— spicatus, *Simpson*.	——— armatum, *Sowerby*.
——— Stokesi (*Simpson*).	Amaltheus margaritatus, *Montfort*.
——— sublævis (*Simpson*).	Non-liassic.
——— subnodosus, *Young and Bird*.	Amaltheus margaritatus, *Montfort*.
——— subtriangularis, *Young and Bird*.	Ægocèras armatum, *Sowerby*.
——— sulcatus, *Simpson*.	——— Charmassei, *D'Orbigny*.
——— tenellus, *Simpson*.	Arietites Collenoti, *D'Orbigny*.
——— tenuicostatus, *Young and Bird*.	Lytoceras lineatum, *Schlotheim*.
——— tenuispinus, *Simpson*.	? Ægoceras brevispinum, *Sowerby*.
——— transformatus, *Simpson*.	Arietites Sauzeanus, *D'Orbigny*.
——— tubellus (pars), *Simpson*.	Ægoceras armatum, *Sowerby*.

SYNONYMS.	ADOPTED NAMES.
Scalaria aureus, *Simpson.*	Cerithium Slatteri, *Tate.*
——— ferreus, *Simpson.*	Chemnitzia citharella, *Tate.*
——— Youngi, *Simpson.*	——— Youngi, *Simpson.*
Trochus anglicus (*Simpson*).	Pleurotomaria similis, *Sowerby.*
——— pusillus, *Simpson.*	
Turbo adductus, *Simpson.*	Encyclus undulatus, *Phillips.*
——— cirroideus, *Young and Bird.*	Cryptænia expansa, *Sowerby.*
——— concinnus, *Simpson.*	Encyclus imbricatus, *Sowerby*, sp.
——— exemptus, *Simpson.*	Hydrobia solidula, *Dunker.*
——— neglectus, *Simpson.*	Euomphalus minutus, *Schübler.*
——— rugosus, *Simpson.* }	Encyclus undulatus, *Phillips.*
——— undulatus, *Phillips.* }	
Turritella defossus, *Simpson.*	Turritella Dunkeri, *Terquem.*

LAMELLIBRANCHIATA.

Amphidesma æquale, *Simpson.*	Pleuromya æqualis, *Simpson.*
——— concavum, *Simpson.*	Gresslya striata, *Agassiz.*
——— contractum, *Simpson.*	Pleuromya contracta, *Simpson.*
——— costatum, *Young and Bird.*	——— costata, *Young and Bird.*
——— donaciforme, *Phillips.*	Gresslya donaciformis, *Phillips.*
——— intermedium, *Simpson.*	——— intermedia, *Simpson.*
——— irregulare, *Simpson.*	——— donaciformis, *Phillips.*
——— læve, *Simpson.* }	——— Seebachii, *Brauns.*
——— maculatum, *Simpson.* }	
——— nitidum, *Simpson.*	Leda galathea, *D'Orbigny.*
——— punctatum, *Simpson.*	Gresslya punctata, *Simpson.*
——— rotundatum, *Phillips.*	{ ——— rotundata, *Phillips.*
	{ ——— intermedia, *Simpson.*
——— rotundatum (*Simpson*).	——— abducta, *Phillips.*
——— subtruncatum, *Simpson.*	——— Seebachii, *Brauns.*
——— ventricosum, *Simpson.*	Pleuromya ovata, *Römer.*
Astarte minima (pars), *Phillips.*	Astarte striatosulcata, *Römer.*
Avicula crescens, *Young and Bird.*	Monotis inæquivalvis, *Sowerby.*
——— crescens (*Simpson*).	——— substriatus, *Münster.*
——— cygnipes, *Young and Bird.*	——— cygnipes, *Young and Bird.*
——— echinata ?, *Phillips.*	——— substriatus, *Münster.*
——— inæquivalvis, *Phillips.*	——— inæquivalvis, *Sowerby.*
——— minima, *Simpson.* }	——— substriatus, *Münster.*
——— nitescens, *Simpson.* }	
——— tumidulus, *Simpson.* }	
——— Roseburiensis, *Young and Bird.*	——— inæquivalvis, *Sowerby.*
Cardinia costata, *Simpson.*	Cardinia Listeri, *Sowerby.*
——— membranacea, *Simpson.*	Pleuromya sp., indeterminate.
Cardita lævis, *Young and Bird.*	Cardinia lævis, *Young and Bird.*
——— margaritacea, *Young and Bird.*	?
——— nitida, *Young and Bird.*	Ceromya exarata, *Tate.*
——— producta, *Young and Bird.*	?
Cardium deltoideum, *Young and Bird.*	Cardium truncatum, *Sowerby.*
——— multicostatum, *Phillips.*	Cardita multicostata, *Phillips.*
——— truncatum (*Phillips*). }	Protocardium truncatum, *Sowerby.*
——— triangulare, *Young and Bird.* }	
——— securiforme, *Simpson.*	Cypricardia cucullata, *Münster.*
Corbis uniformis, *Phillips.*	? Leda subovalis, *Goldfuss.*
Corbula æquivalvis, *Simpson.* }	Unicardium cardioides, *Phillips.*
——— cardioides, *Phillips.* }	
——— deltoidea, *Simpson.* }	
——— inæquivalvis, *Simpson.* }	

SYNONYMS.	ADOPTED NAMES.
Crenatula ventricosa, *Young and Bird.*	Inoceramus ventricosus, *Sowerby.*
Cucullæa cuspidata, *Simpson.*	Macrodon intermedius, *Simpson.*
—— expansa, *Simpson.*	
—— incrassata, *Simpson.*	
—— intermedia, *Simpson.*	
—— obtusalis, *Simpson.*	Cucullæa Münsteri, *Zieten.*
—— securiformis, *Simpson.*	Cypricardia cucullata, *Münster.*
—— triangularis, *Simpson.*	Protocardium oxynoti, *Quenstedt.*
Gervillia ? rugata, *Simpson.*	Inoceramus dubius, *Sowerby.*
Gryphæa depressa, *Phillips.*	Gryphæa cymbium, *Lamarck.*
—— incurva, *Young and Bird.*	—— arcuata, *Lamarck.*
—— MacCullochi, *Phillips.*	—— cymbium, *Lamarck.*
—— orbicularis, *Simpson.*	
Isocardia lævis, *Simpson.*	Cardinia lævis, *Young and Bird.*
—— nitida, *Simpson.*	Ceromya exarata, *Tate.*
Lima irregularis, *Simpson.*	Lima Hermanni, *Voltz.*
—— ? rusviciensis, *Simpson.*	Pecten æquivalvis, *Sowerby.*
Modiola curvatus, *Simpson.*	Modiola scalprum, *Sowerby.*
—— ensis, *Simpson.*	Myaconcha decorata, *Goldfuss.*
—— gibbosus, *Simpson.*	? Modiola Hillana, *Sowerby.*
—— pallidus, *Simpson.*	Modiola subcancellata, *Buvignier.*
—— plicata, *Phillips.*	—— scalprum, *Sowerby.*
—— pygmæus, *Simpson.*	? —— numismalis, *Oppel ?*
—— rusticus, *Simpson.*	Hippopodium ponderosum, *Sowerby.*
—— siliqua, *Young and Bird.*	Modiola scalprum, *Sowerby.*
—— similis, *Simpson.*	Hippopodium ponderosum, *Sowerby.*
Mya æquilateralis, *Simpson.*	Gresslya ? sp.
—— antiqua, *Simpson.*	Arcomya ? sp.
—— dubia, *Simpson.*	Gresslya intermedia, *Simpson.*
—— ferruginea, *Simpson.*	Pleuromya costata, *Young and Bird.*
—— hispida, *Simpson.*	Arcomya hispida, *Simpson.*
—— literata, *Phillips.*	Goniomya hybrida, *Goldfuss.*
Mytilus cuneatus, *Simpson.*	Modiola scalprum, *Sowerby.*
—— hippocampus, *Young and Bird.*	Hippopodium ponderosum, *Sowerby.*
—— edulis ? (*Young and Bird*).	Inoceramus dubius, *Sowerby.*
Nucula complanata, *Phillips.*	? Leda complanata, *Goldfuss.*
—— cymbula, *Simpson.*	—— galathea, *D'Orbigny.*
—— dura, *Simpson.*	
—— longicaudata, *Simpson.*	—— graphica, *Tate ?*
—— minor, *Simpson.*	—— minor, *Simpson.*
—— ovum, *Phillips.*	Leda ovum, *Sowerby.*
—— rostrata, *Young and Bird.*	
—— ? subtriangularis, *Simpson.*	Gresslya striata, *Agassiz.*
—— tellinæformis, *Simpson.*	Leda æquilatera, *Koch and Dunker.*
Ostrea concinna, *Simpson.*	Gryphæa cymbium, *Lamarck.*
—— inflata, *Simpson.*	
—— patellæformis, *Simpson.*	
—— tumidulosus, *Simpson.*	
—— saltviciensis, *Simpson.*	Inoceramus dubius, *Sowerby.*
Pecten aheneus, *Simpson.*	Pecten æquivalvis, *Sowerby.*
—— cygnipes, *Young and Bird.*	Monotis cygnipes, *Young and Bird.*
—— dichotomus, *Simpson.*	Pecten priscus, *Schlotheim.*
—— interstinctus, *Simpson.*	
—— lamellosus, *Young and Bird.*	—— lunularis, *Römer.*
—— lens, *Phillips.*	—— substriatus, *Römer.*
—— major, *Young and Bird.*	—— æquivalvis, *Sowerby.*
—— multicostatus, *Simpson.*	—— æqualis, *Quenstedt.*
—— planus, *Simpson.*	—— lunularis, *Römer.*
—— pulchellus, *Simpson.*	

SYNONYMS.	ADOPTED NAMES.
Pecten punctatus, *Simpson.* } ——— reticularis, *Simpson.* }	Pecten substriatus, *Römer.*
——— rudis, *Simpson.* } ——— sublævis, *Young and Bird.* }	——— æquivalvis, *Sowerby.*
——— sublævis (*Phillips*).	——— priscus, *Schlotheim.*
Perna quadrata (*Young and Bird*).	Perna Lugdunensis, *Dumortier.*
Pholadomya antiquata, *Simpson.*	Pholadomya decorata, *Zieten.*
——— concinna, *Simpson.*	——— ventricosa, *Agassiz.*
——— costata, *Simpson.*	——— not Liassic.
——— elongata, *Simpson.*	——— decorata.
——— gallina, *Simpson.*	Gresslya? sp. indet.
——— gibbosa, *Simpson.*	Pholadomya Simpsoni, *Tate.*
——— lævis, *Simpson.*	Gresslya intermedia, *Simpson.*
——— obliquata, *Phillips.*	——— Seebachii, *Brauns?*
——— producta, *Simpson.* } ——— recurva, *Simpson.* }	Pholadomya ambigua, *Sowerby.*
——— rostellata, *Simpson.* } ——— rostrata, *Simpson.* }	Gresslya lunulata, *Tate.*
——— truncata, *Simpson.*	Pholadomya decorata, *Zieten.*
Pinna quadrata, *Simpson.*	Pinna folium, *Young and Bird.*
Plagiostoma excavatum, *Simpson.*	Lina Toarcensis? *Deslongchamps.*
Plagiostoma multicostatum, *Simpson.*	Lima Hermanni, *Voltz.*
——— novemcostatum, *Simpson.* } ——— pectenoideum, *Phillips.* }	Limea acuticosta, *Goldfuss.*
——— rusticum, *Young and Bird.*	Lima Hermanni, *Voltz.*
Pullastra antiqua, *Phillips.* } ——— prototypa, *Phillips.* }	Cardinia antiqua, *Phillips.*
——— granata, *Simpson.*	Pleuromya granata, *Simpson.*
——— mediæva, *Simpson.*	Gresslya striata, *Agassiz.*
Placuna ferruginea, *Simpson.*	Plicatula calva? *Deslongchamps.*
Sanguinolaria elegans, *Phillips.*	Pleuromya elegans, *Phillips.*
——— vetusta, *Phillips.*	Arcomya vetusta, *Phillips.*
Tellina cycliformis, *Simpson.*	Venus tenuis, *Koch and Dunker.*
——— striata, *Simpson.*	Lucina limbata, *Terquem and Piette.*
Solen ensis? (*Young and Bird*).	Myaconcha decorata, *Goldfuss.*
Unio acutus, *Young and Bird.*	?
——— abductus (pars), *Phillips.*	Gresslya Seebachii, *Brauns.*
——— concinnus, *Phillips.*	Cardinia concinna, *Sowerby.*
——— costatus, *Young and Bird.*	Pleuromya costata, *Young and Bird.*
——— crassiusculus, *Phillips.*	Cardinia crassiuscula, *Sowerby.*
——— Listeri (*Young and Bird*).	——— Listeri, *Sowerby.*
Venus petricosa, *Simpson.*	Ceromya petricosa, *Simpson.*
——— granata, *Simpson.*	Pleuromya granata, *Simpson.*

PALLIOBRANCHIATA.

Lingula venusta, *Simpson.*	Lingula longovicensis, *Terquem.*
Patella lævis, *Sowerby.*	Discina reflexa, *Sowerby.*
Rhynchonella inconstans (*Young and Bird*).	not Liassic.
Spirifer liassicus, *Simpson.*	Spiriferina Walcottii, *Sowerby.*
——— mediævius, *Simpson.*	not Liassic.
——— recentior, *Simpson.*	Spiriferina Walcottii, *Sowerby.*
Terebratula bidens, *Phillips.*	Rhynchonella lineata, *Young and Bird.*
——— compressa, *Simpson.*	——— tetrahedra, *Sowerby.*
——— hispidula, *Simpson.*	Waldheimia sarthacensis, *D'Orbigny.*
——— mundula, *Simpson.*	Rhynchonella plicatissima, *Quenstedt.*
——— ornithocephala (*Simpson*).	Waldheimia sarthacensis, *D'Orbigny.*

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15. Lingulina tenera	455	31. Marginulina reversa	461
16. ——— striata	455	32. Orbulina universa	472
17. Nodosaria radicula	456		

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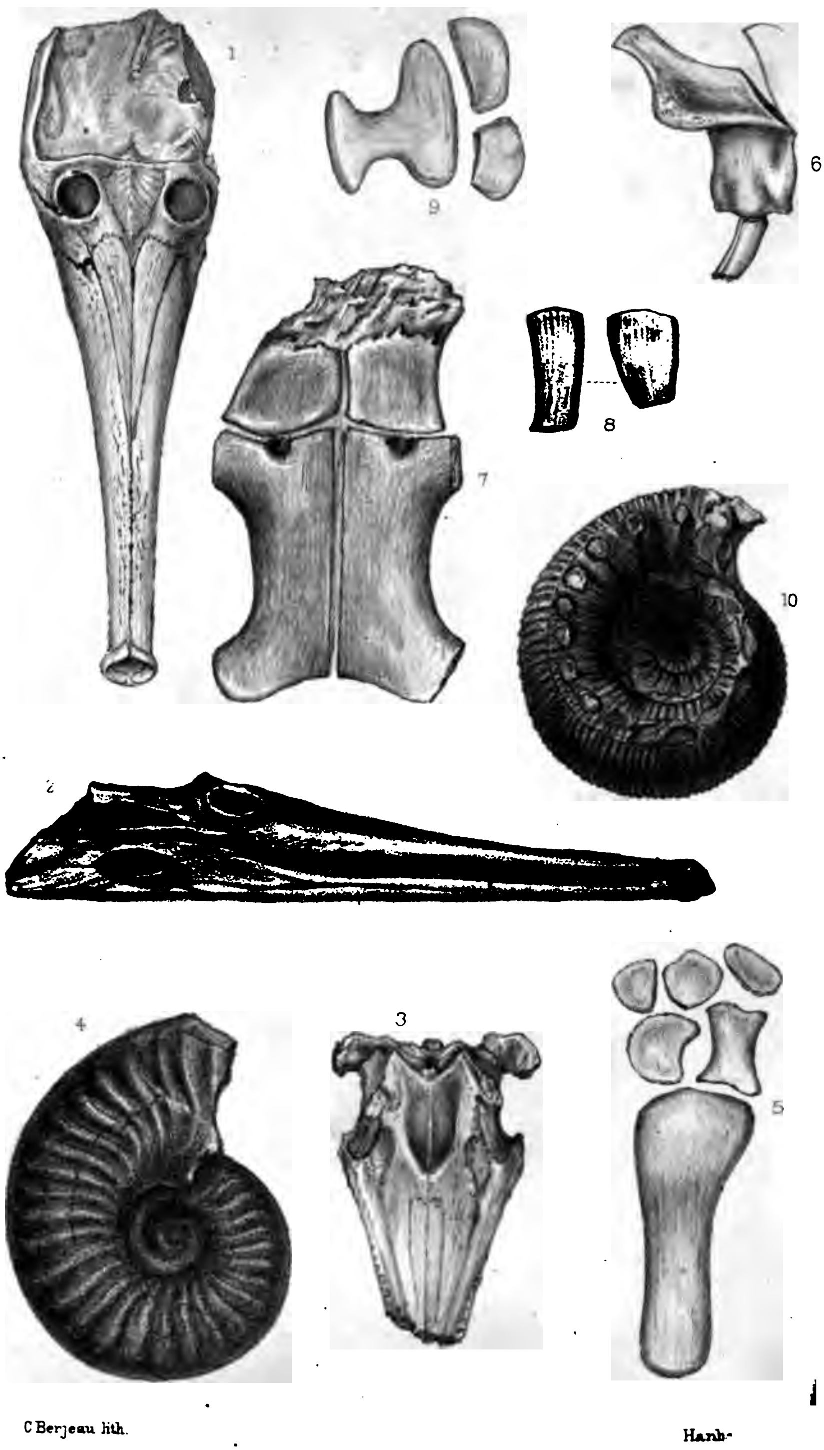
2. Dentalina glandulosa	460	14. ——— crepidula	466
3. ——— rapa	460	15. ——— major	465
4. ——— obliquestriata	460	16. ——— varians	466
5. Marginulina raphanus	462	17. ——— globifera	467
6. ——— picta	462	18. ——— rotulata	467
7. ——— inæquistriata	462	19. Flabellina rugosa	467
8. ——— Römeri	463	20. Frondicularia complanata	468
9. ——— depressa	463	21. ——— intumescens	468
10. Planularia arguta	464	22. ——— Terquemi	468
11. Vaginulina legumen	464	23. ——— sulcata	469
12. Cristellaria pauperata	465	24. ——— nodosaria	469

NOTE.—The greater number of the fossils figured in these plates, where not otherwise specified, are in the Museum of Practical Geology, Jermyn Street.

PLATE I



C Berjeau lith.

Hanh-

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28.	——— funiculosa	461
29.	——— burgundiæ	461
30.	——— nummulina	461
31.	Marginulina reversa	461
32.	Orbulina universa	472

Plate XIX.

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17.	——— globifera	467
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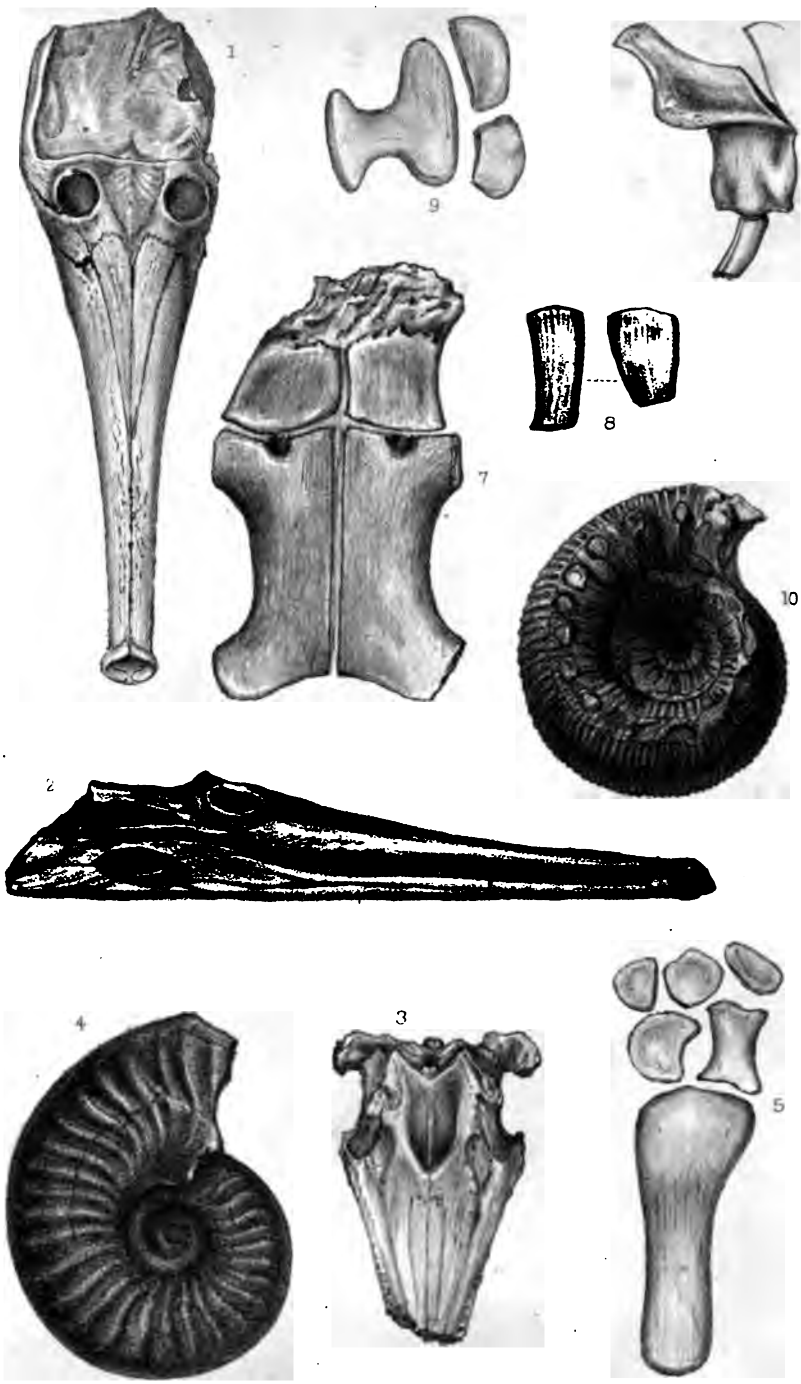
NOTE.—The greater number of the fossils figured in these plates, where not otherwise specified, are in the Museum of Practical Geology, Jermyn Street.

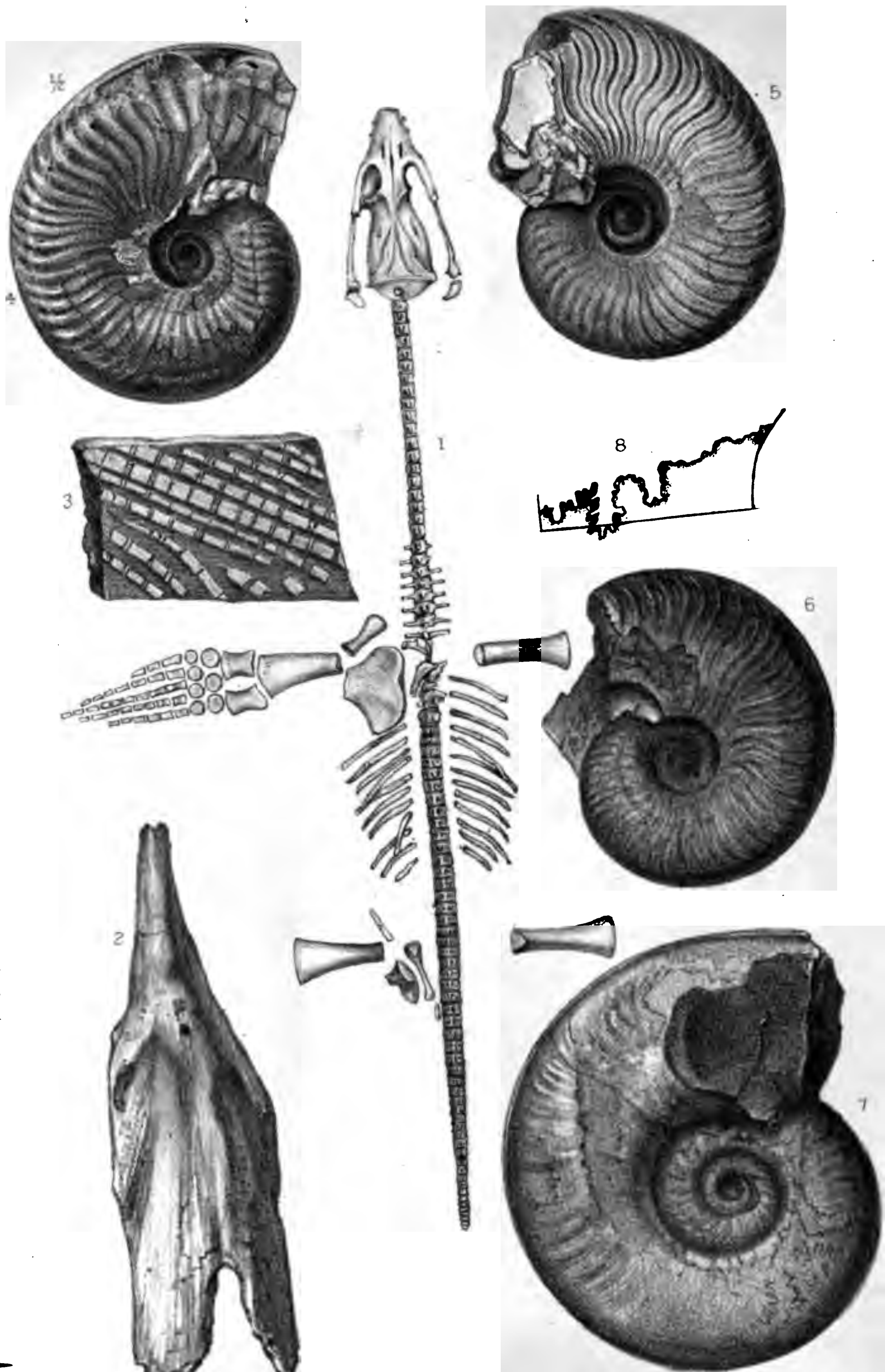
PLATE I



C Berjeau lith.

Hanhart imp.

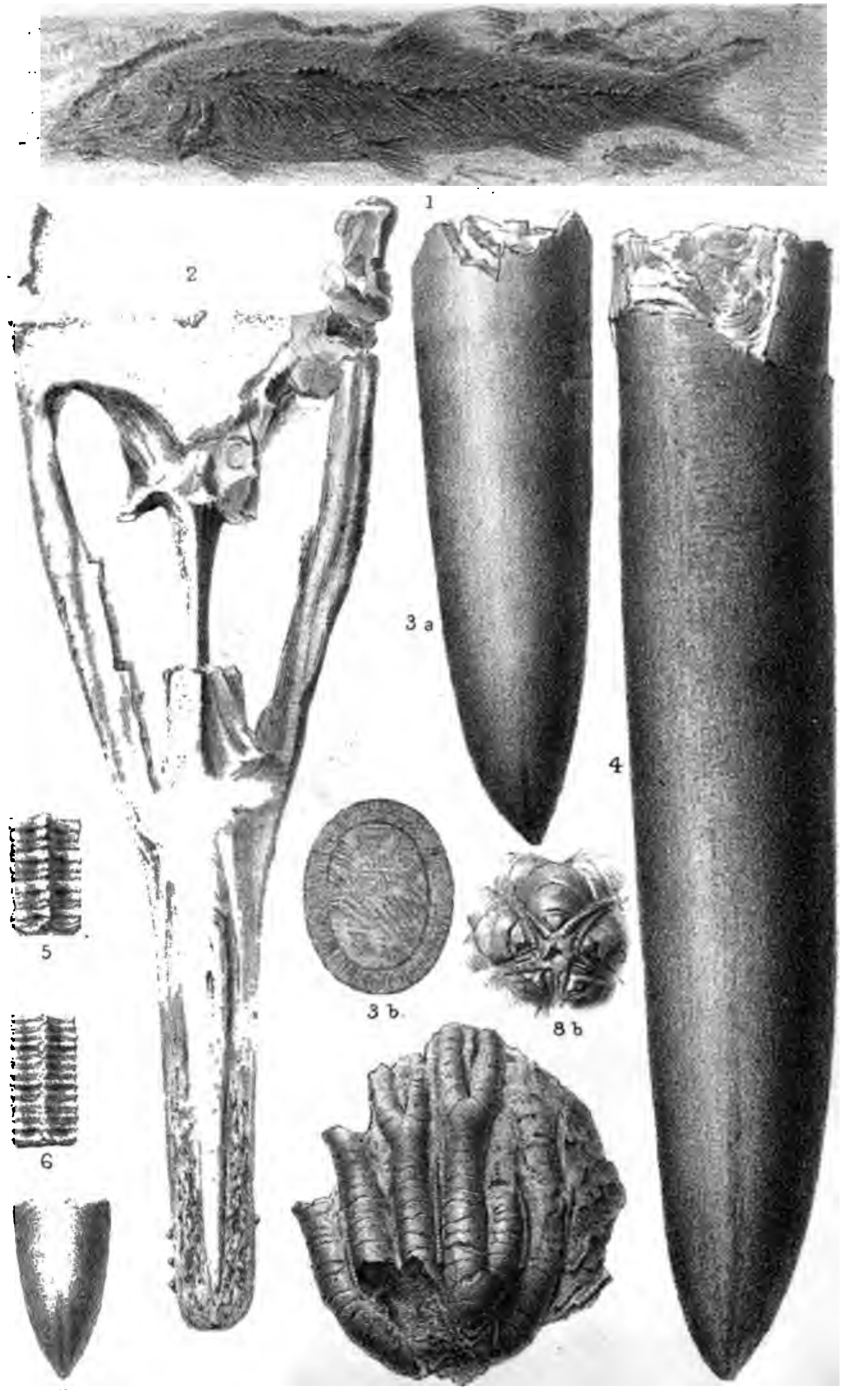
PLATE II.



C.Berjeau lith.

Hanhart imp

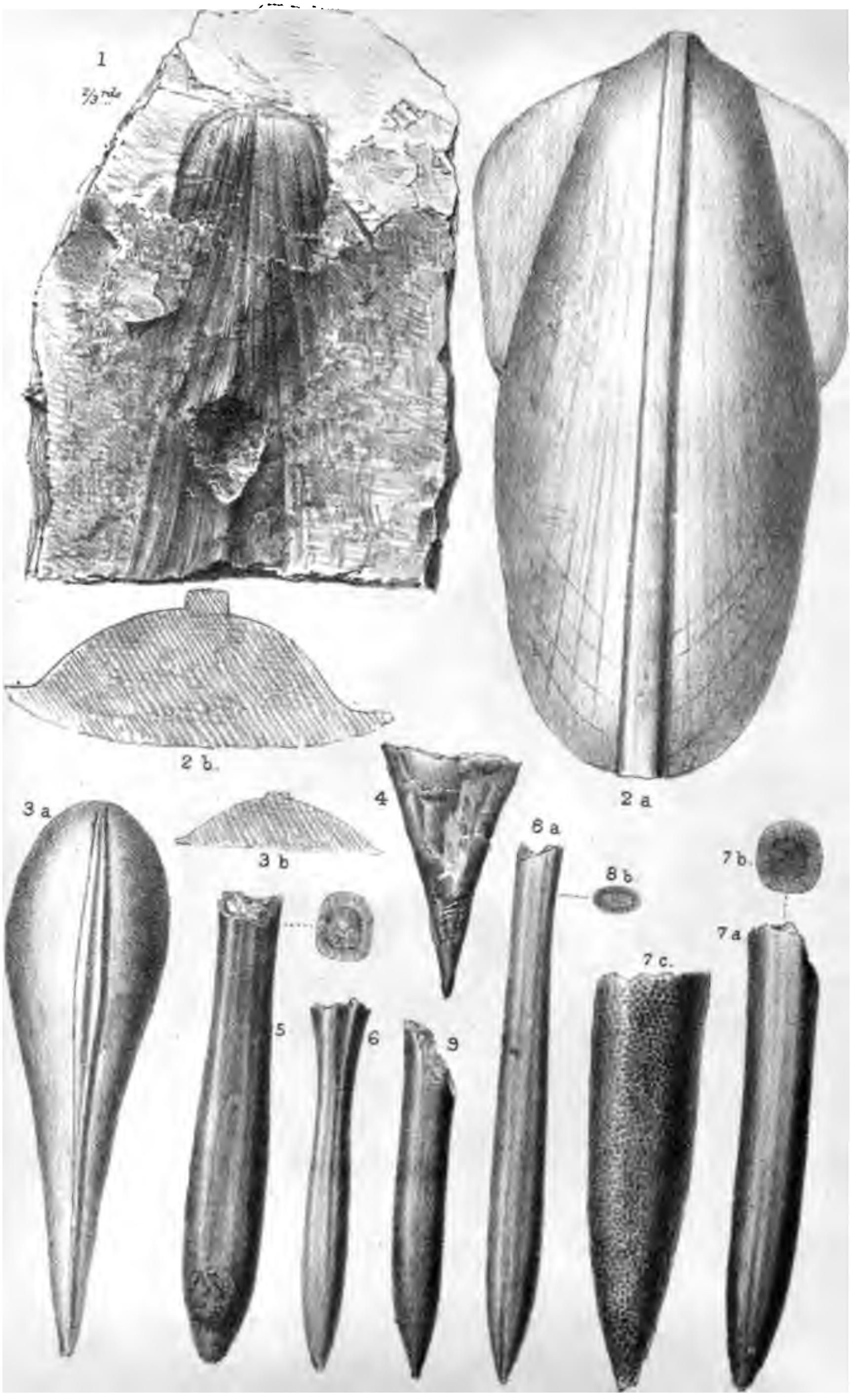
PLATE III



W Purkiss lith

Hanhart imp.

PLATE IV.



W. Purkiss lith.

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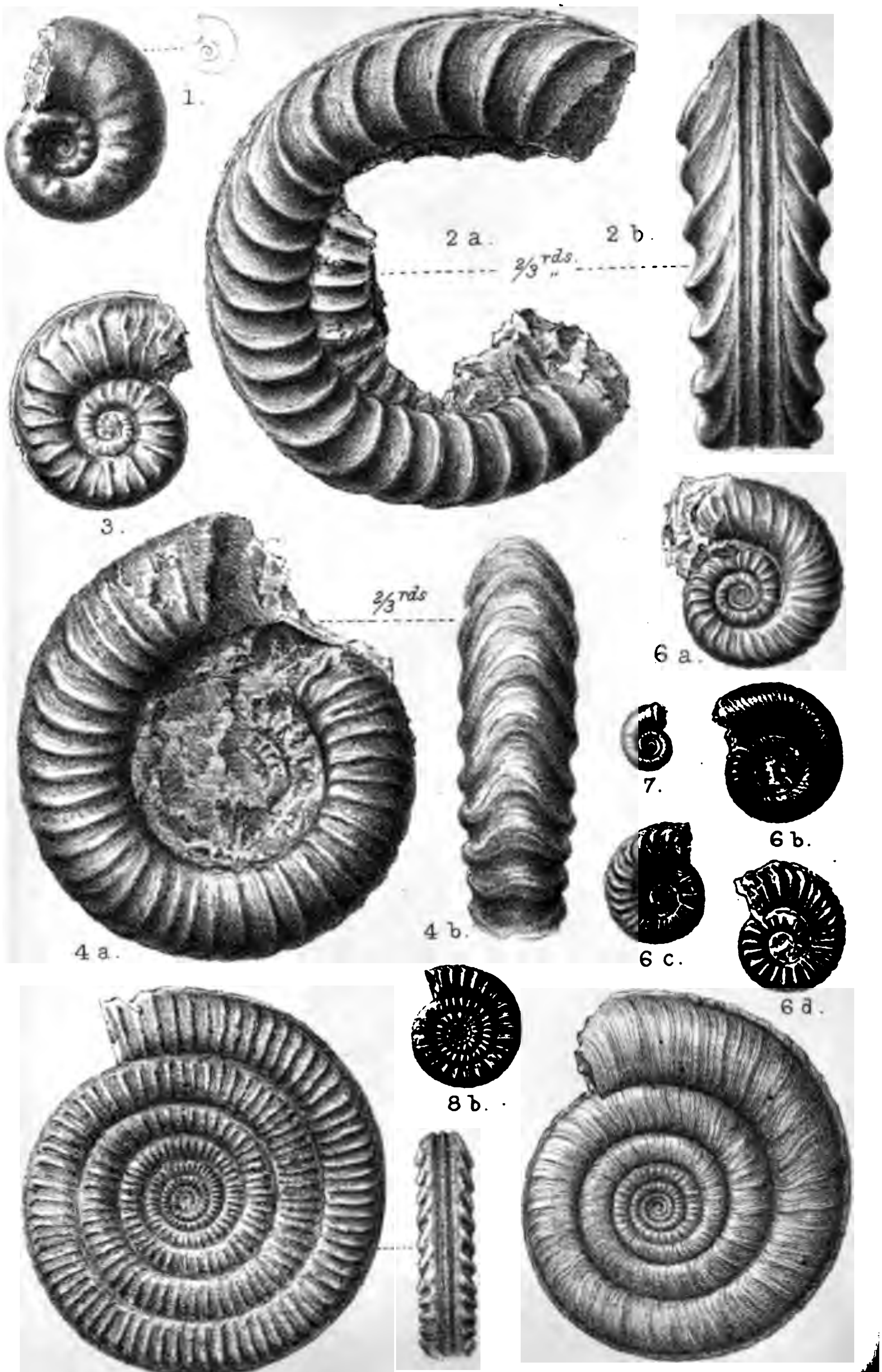
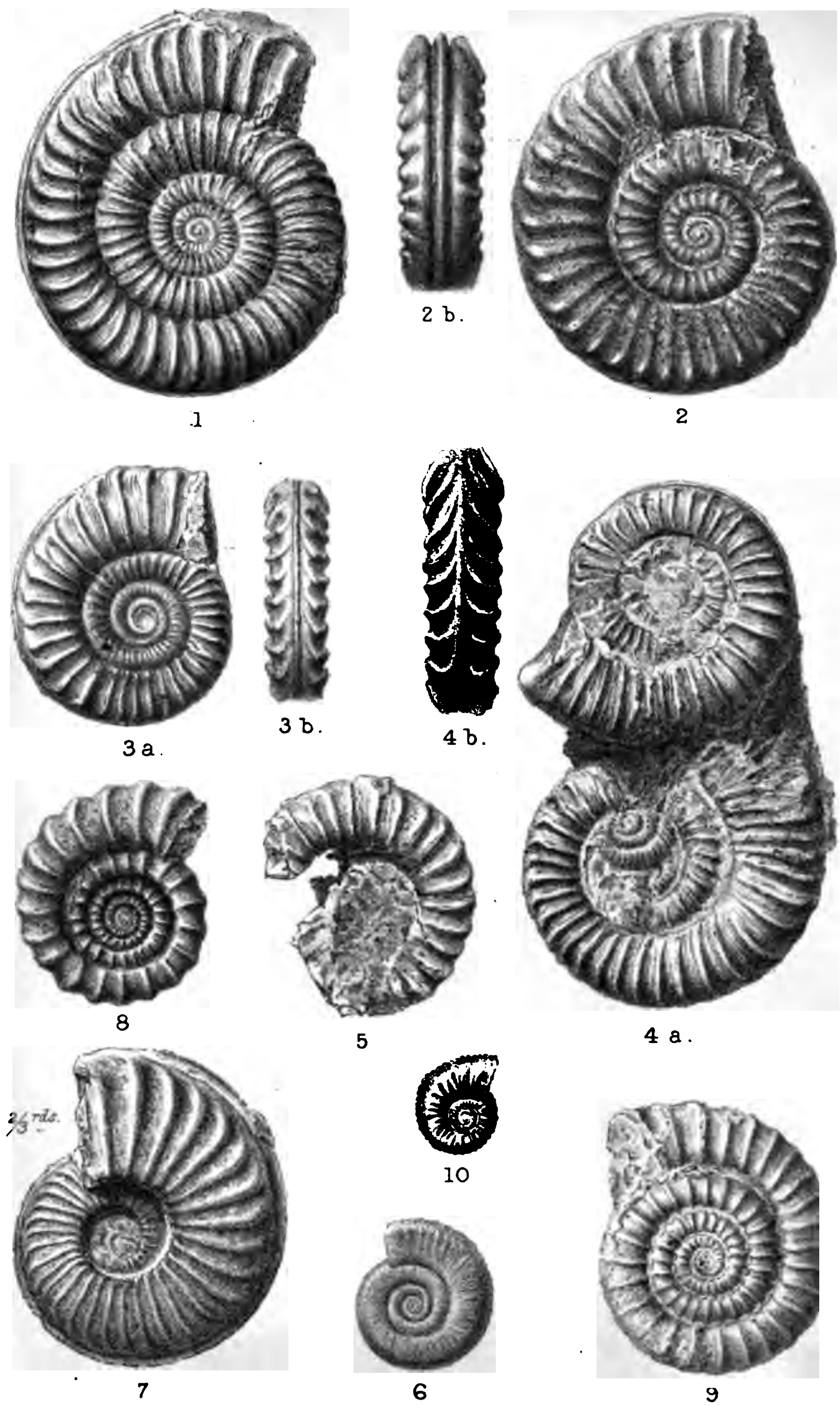
PLATE V.



W. Purkiss lith.

PLATE VI.



W.Purkiss lith.

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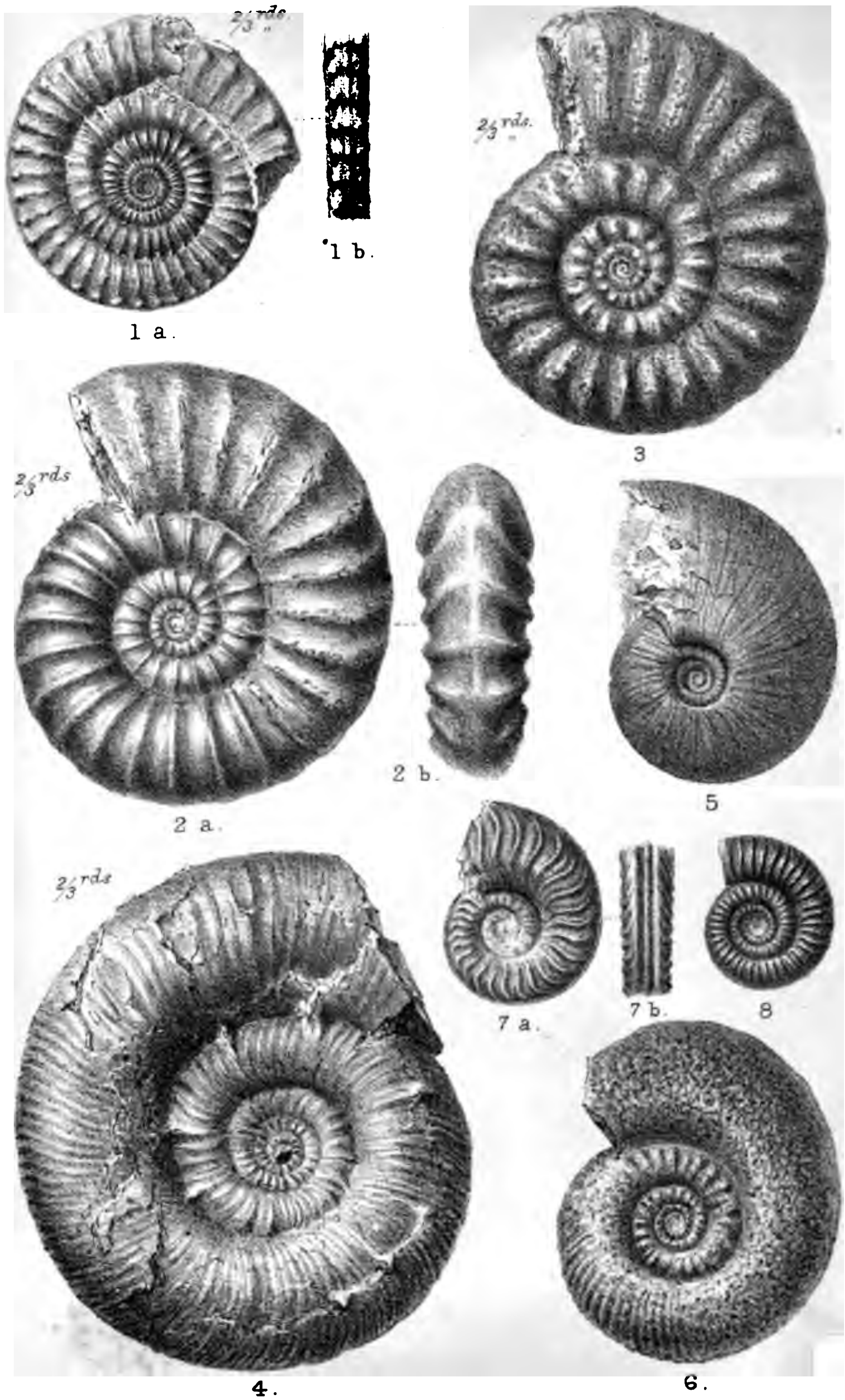
PLATE VII.



W Purkiss lith.

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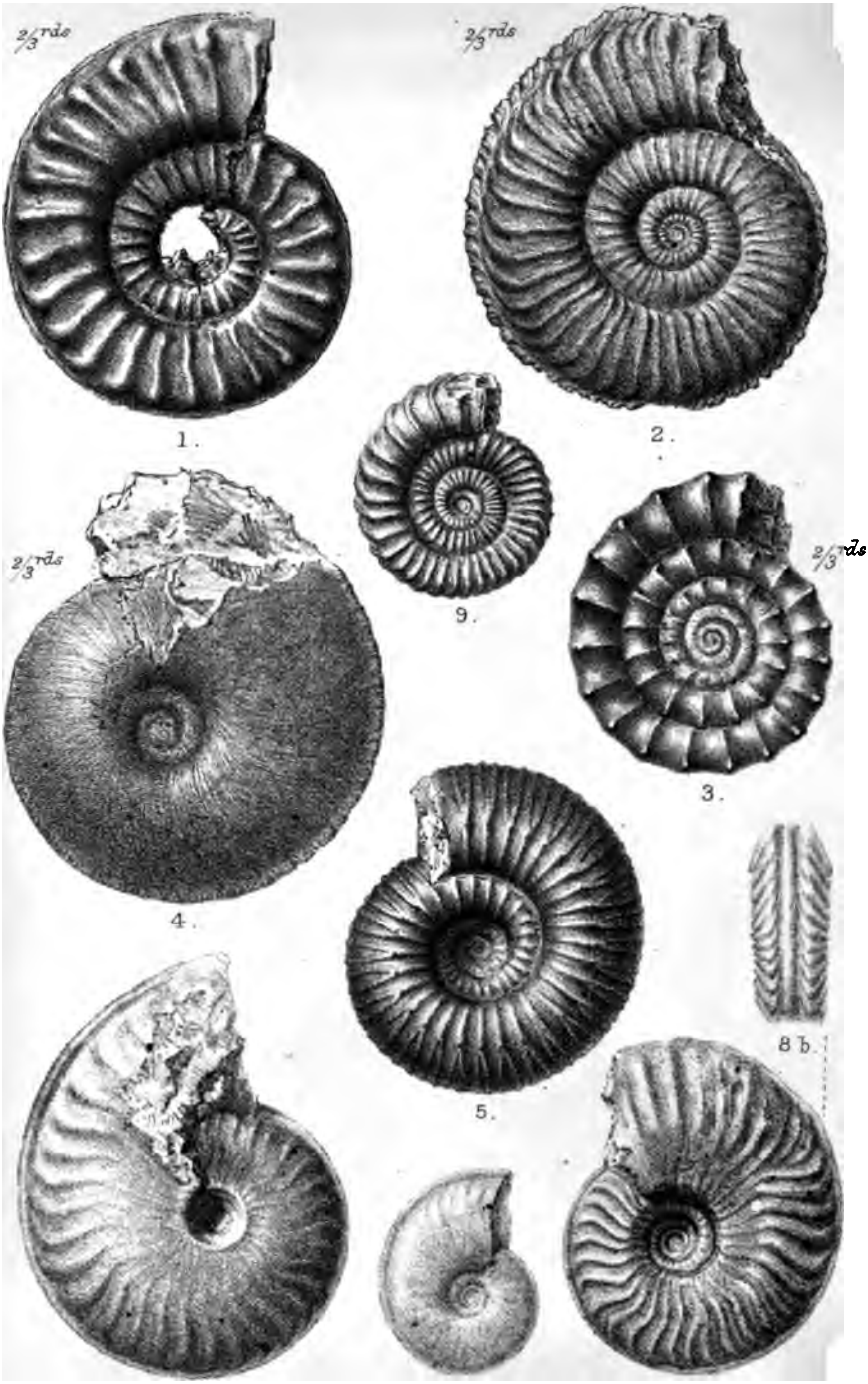
PLATE VIII.



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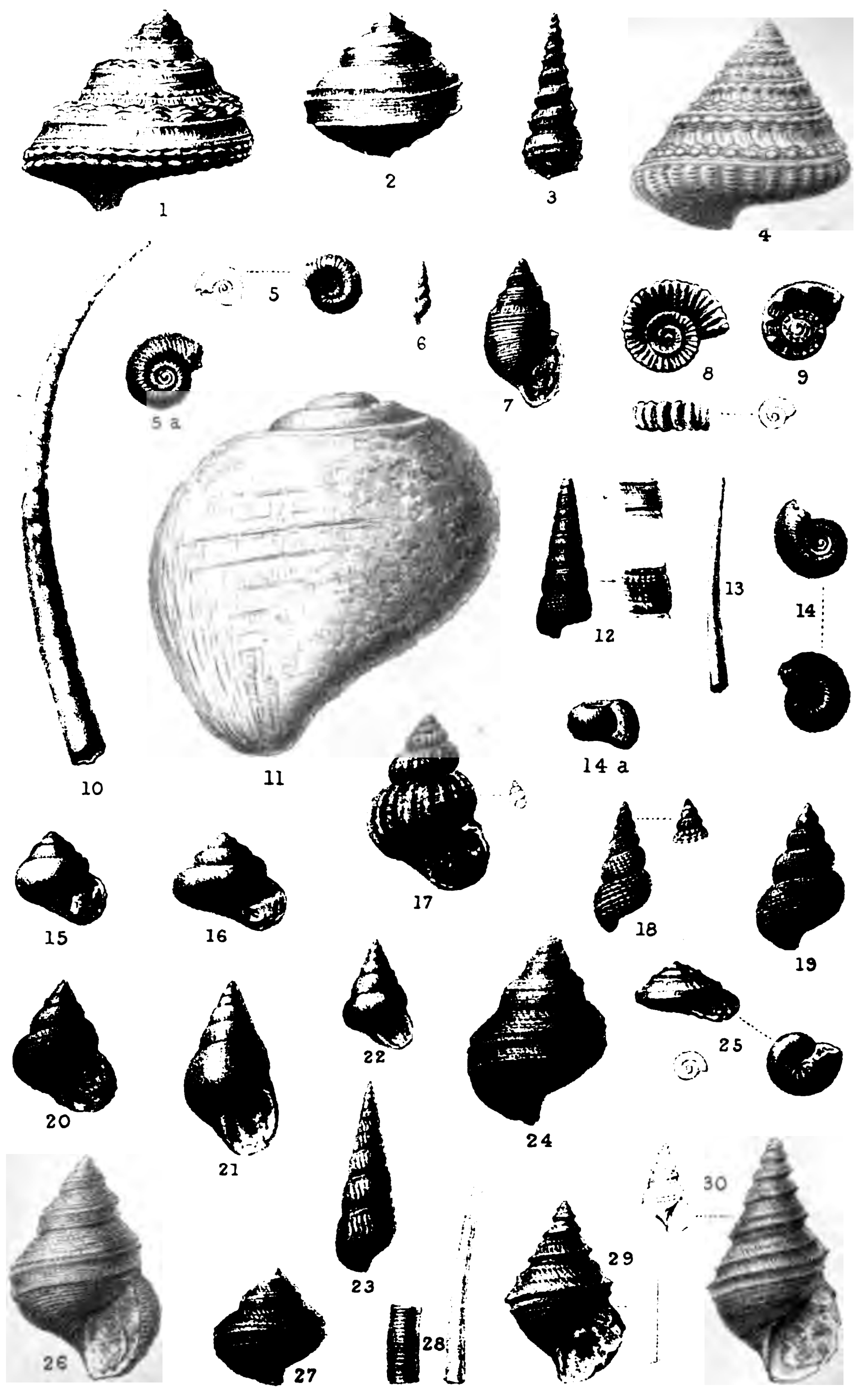
W. Purkiss lith. Hanhart

PLATE IX.



W. Purkiss lith.

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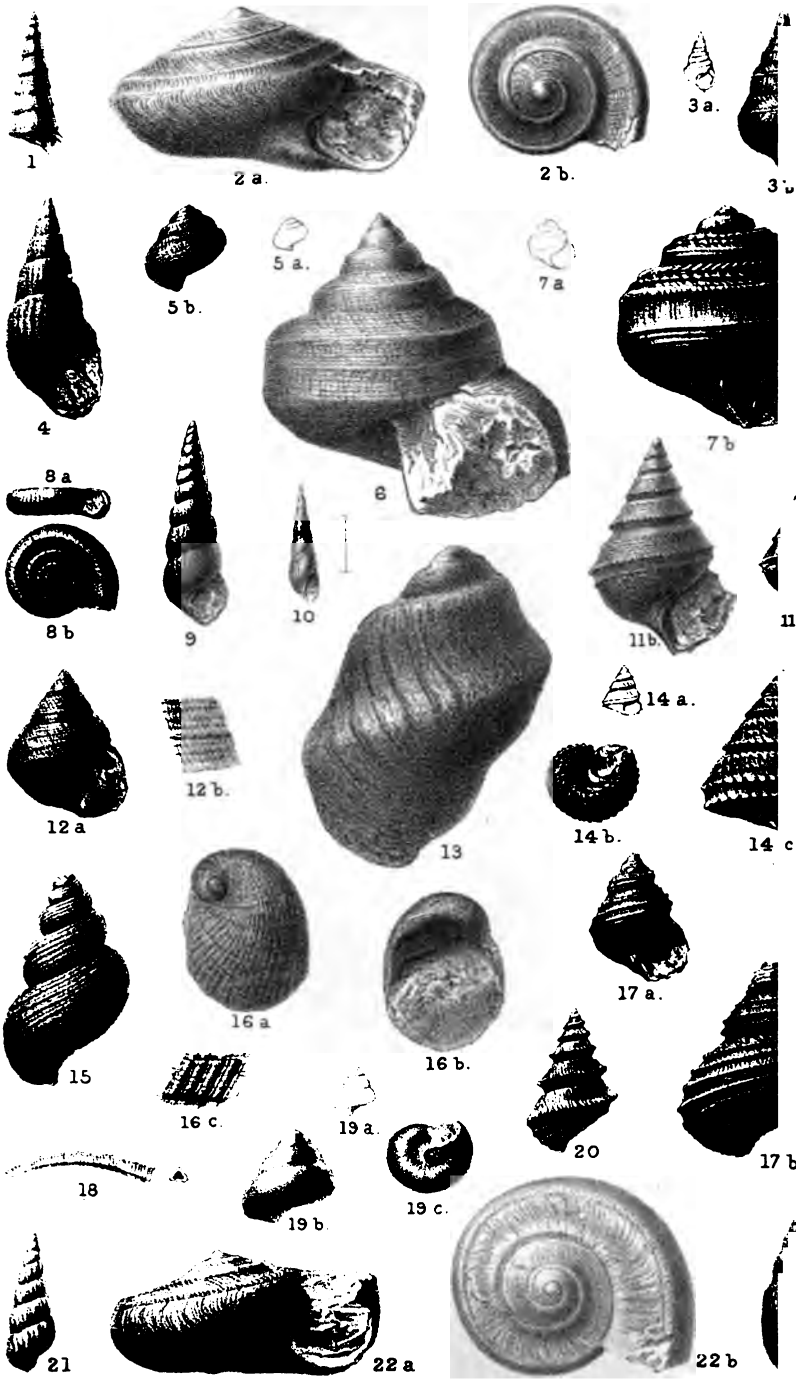
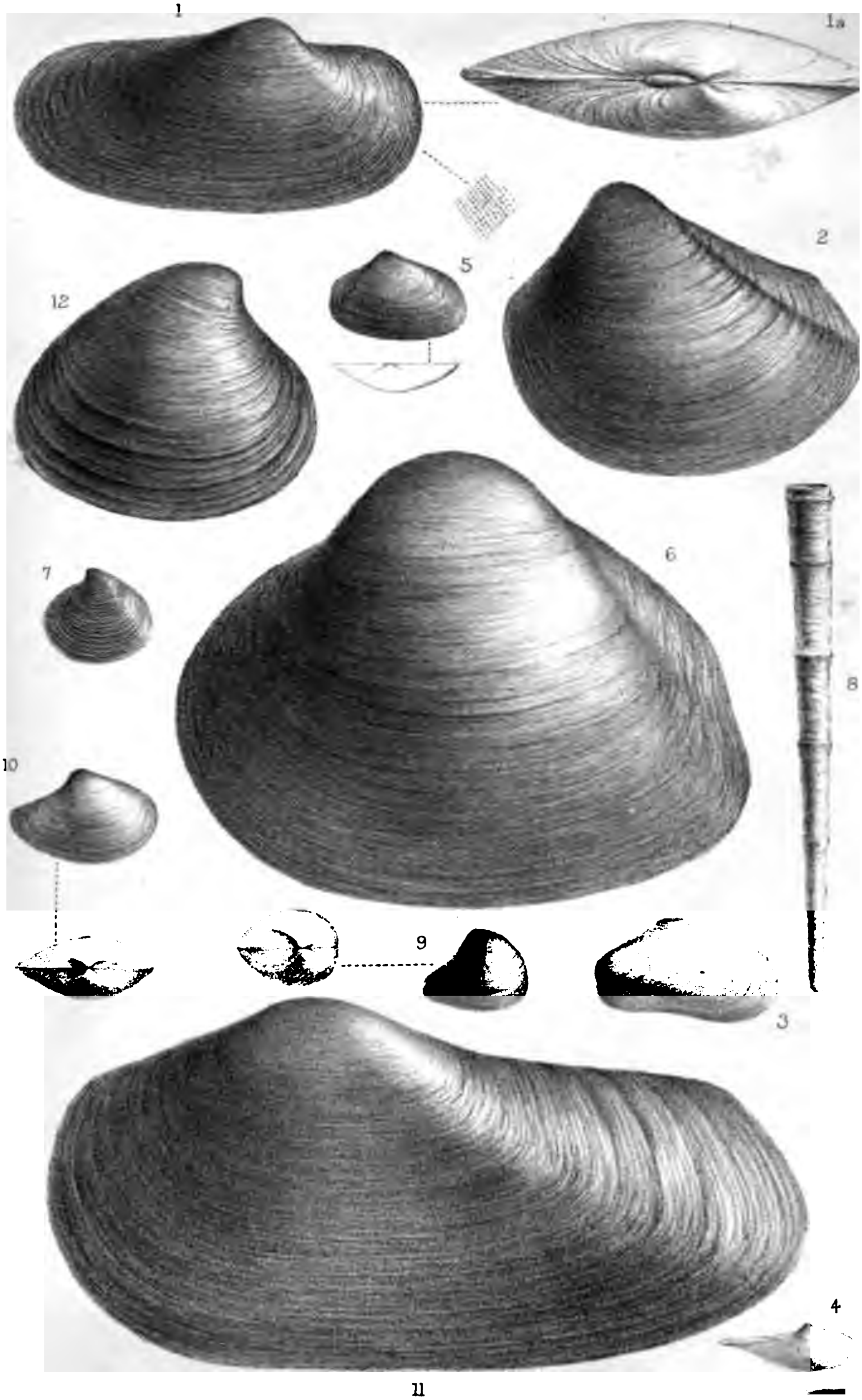
PLATE X.



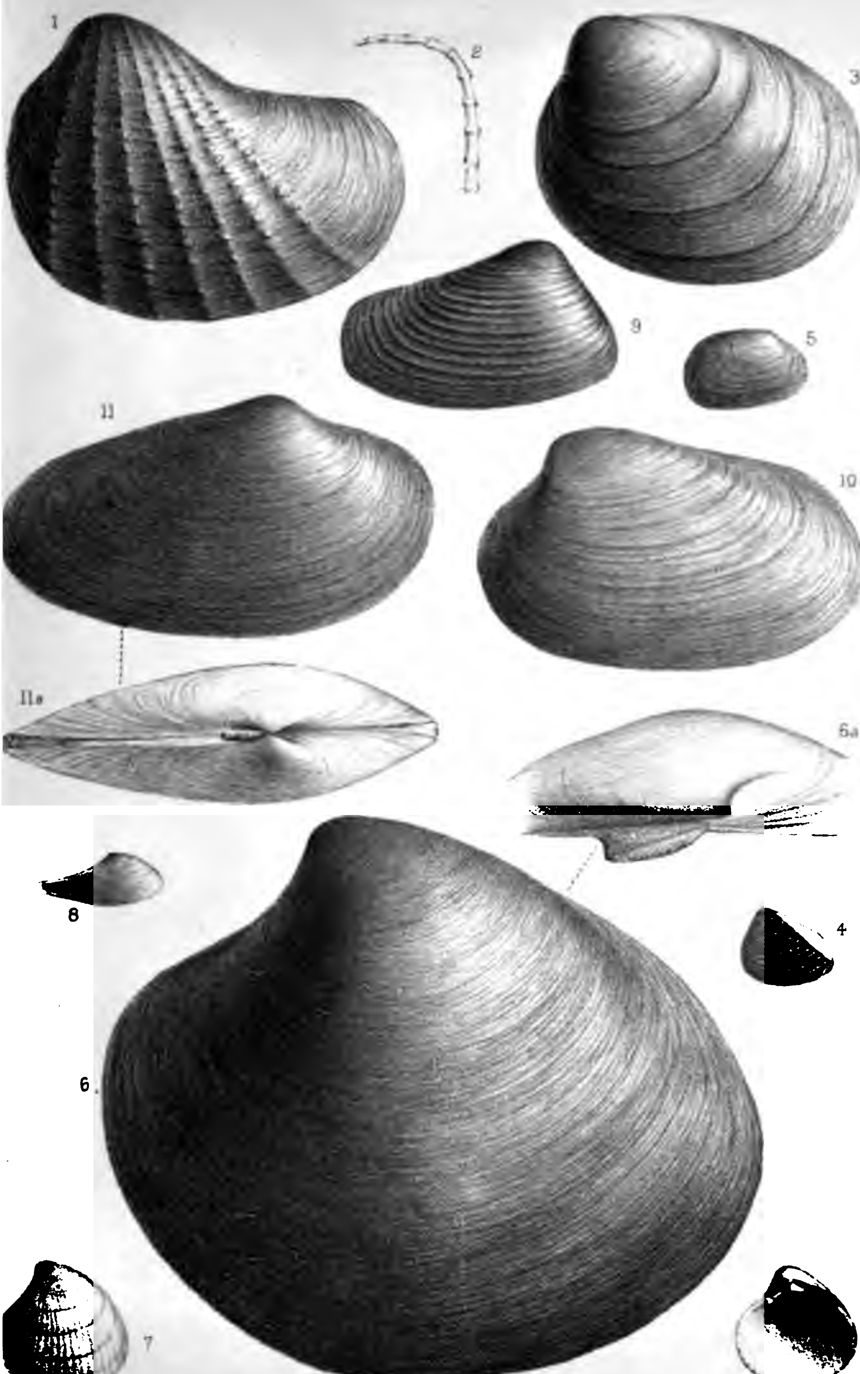
W. Purkiss lith. Hanl

PLATE XI.



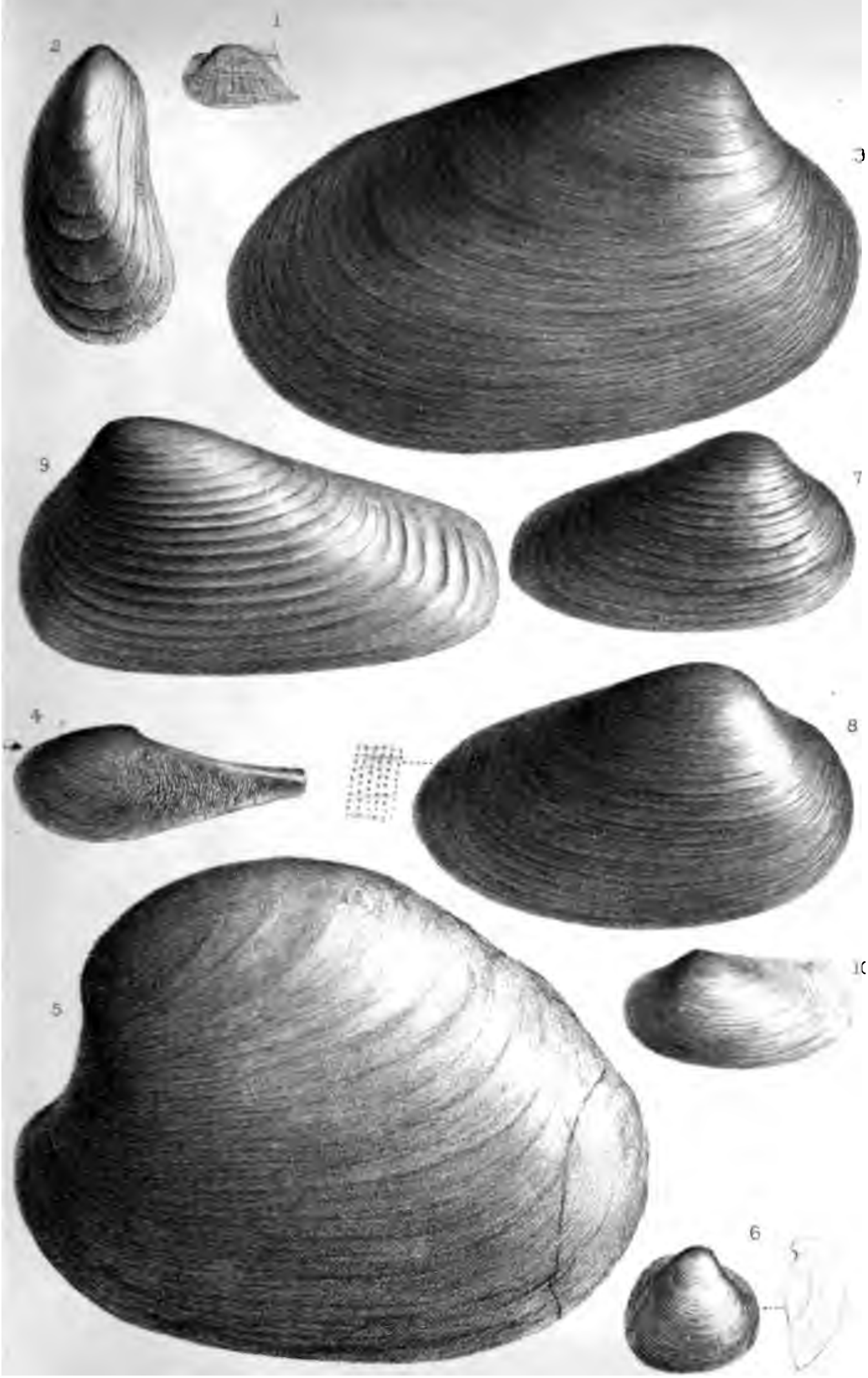
Geo West lith

PLATE XII



Geo. West lith. Hanhart i

PLATE XIII.



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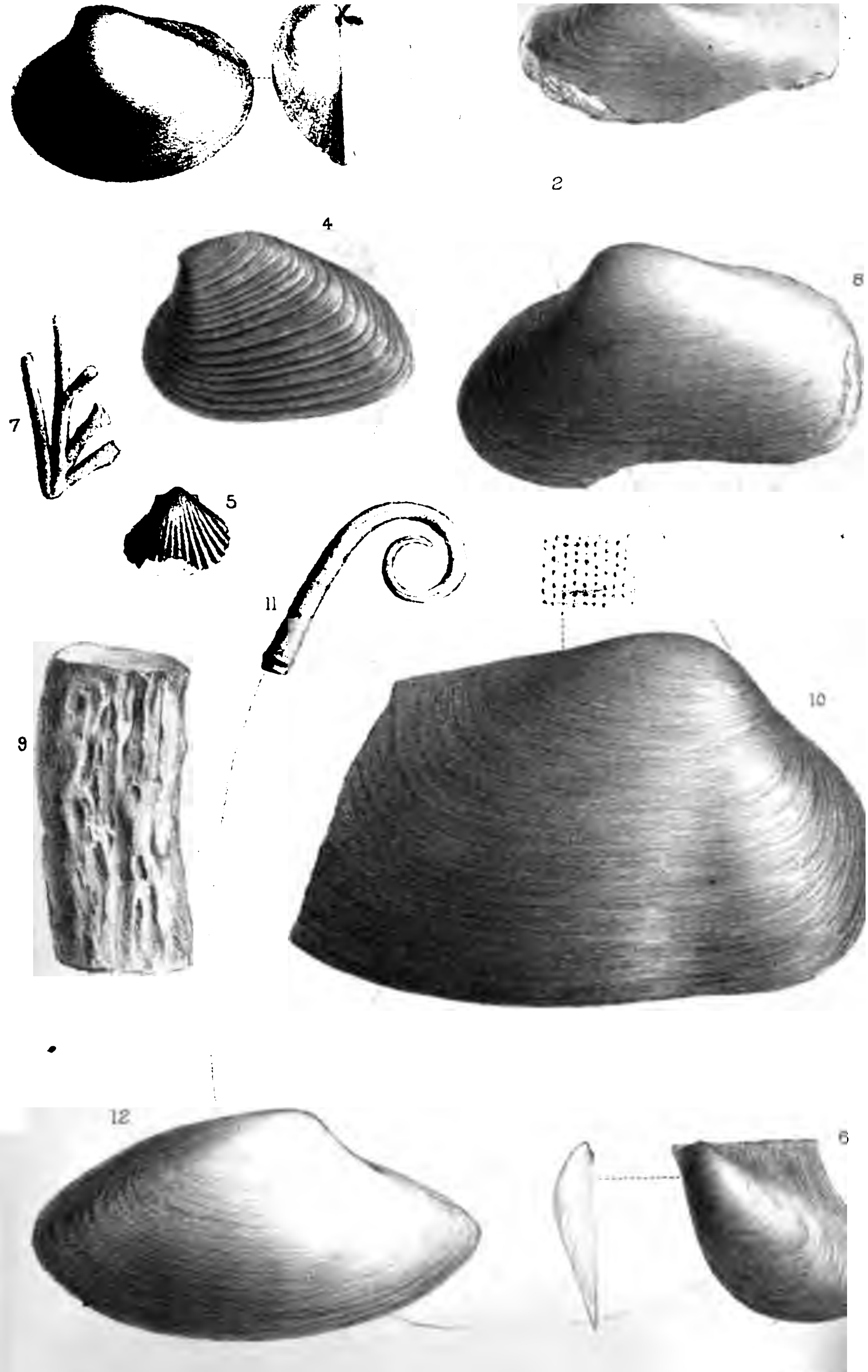

Geo. West lith.

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PLATE XV.

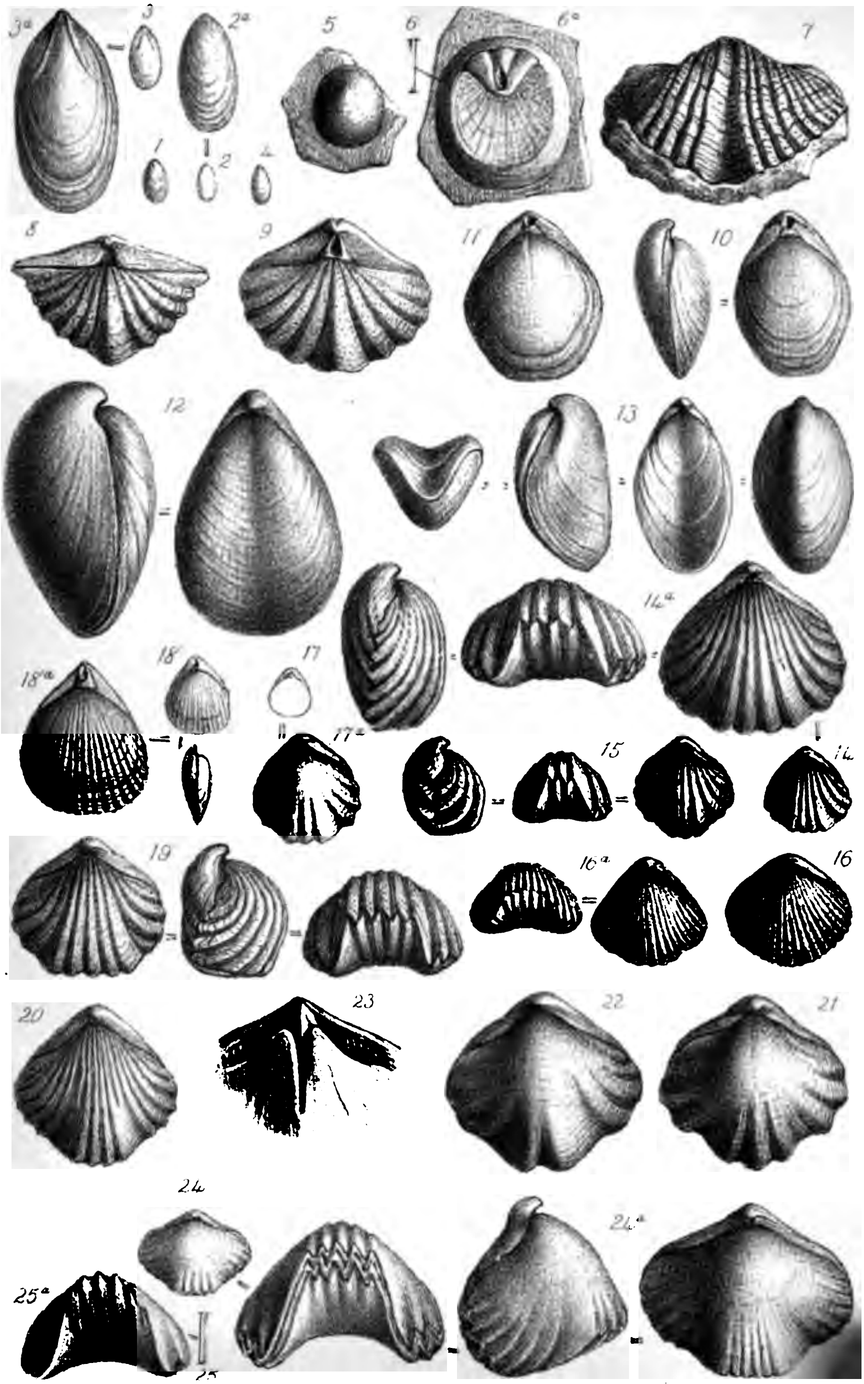

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PLATE XVI.

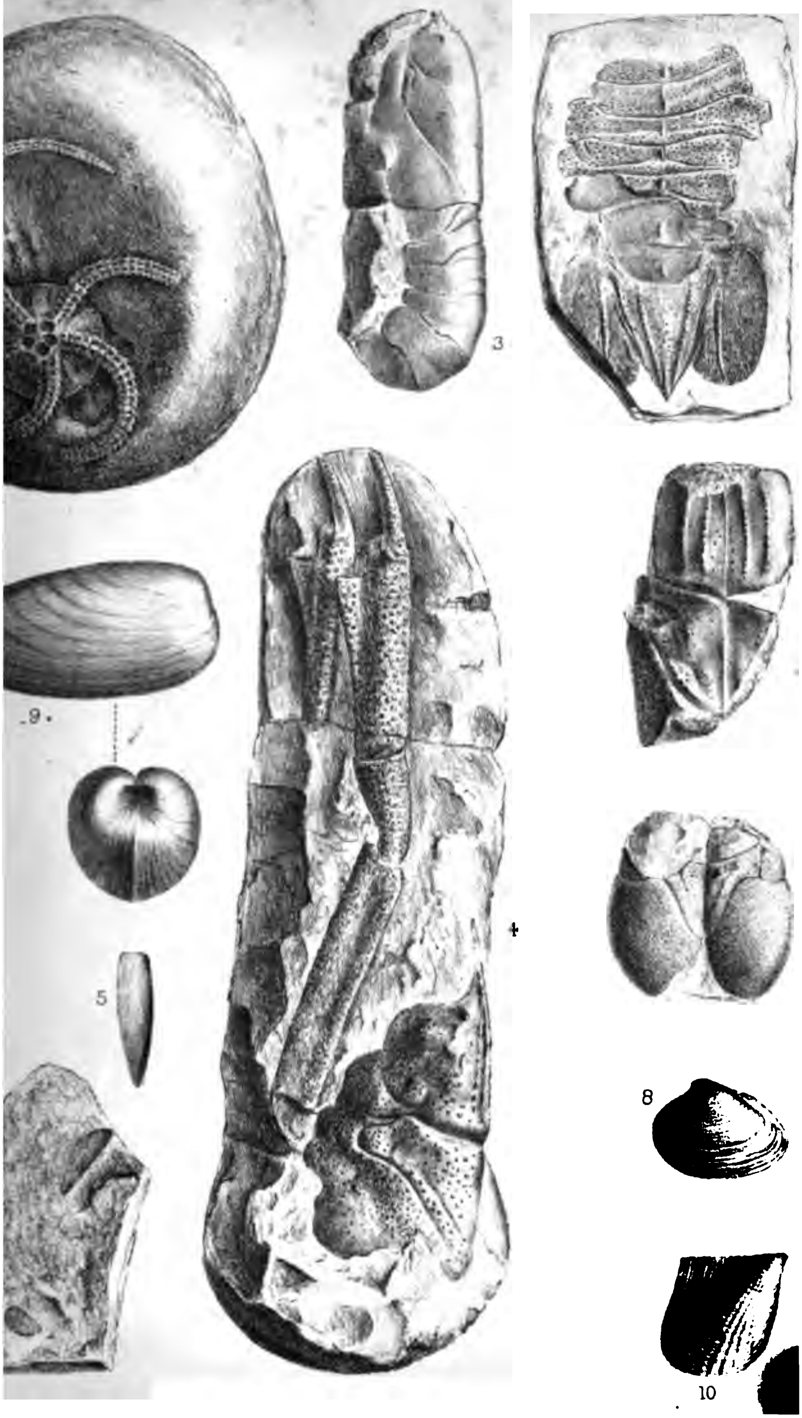

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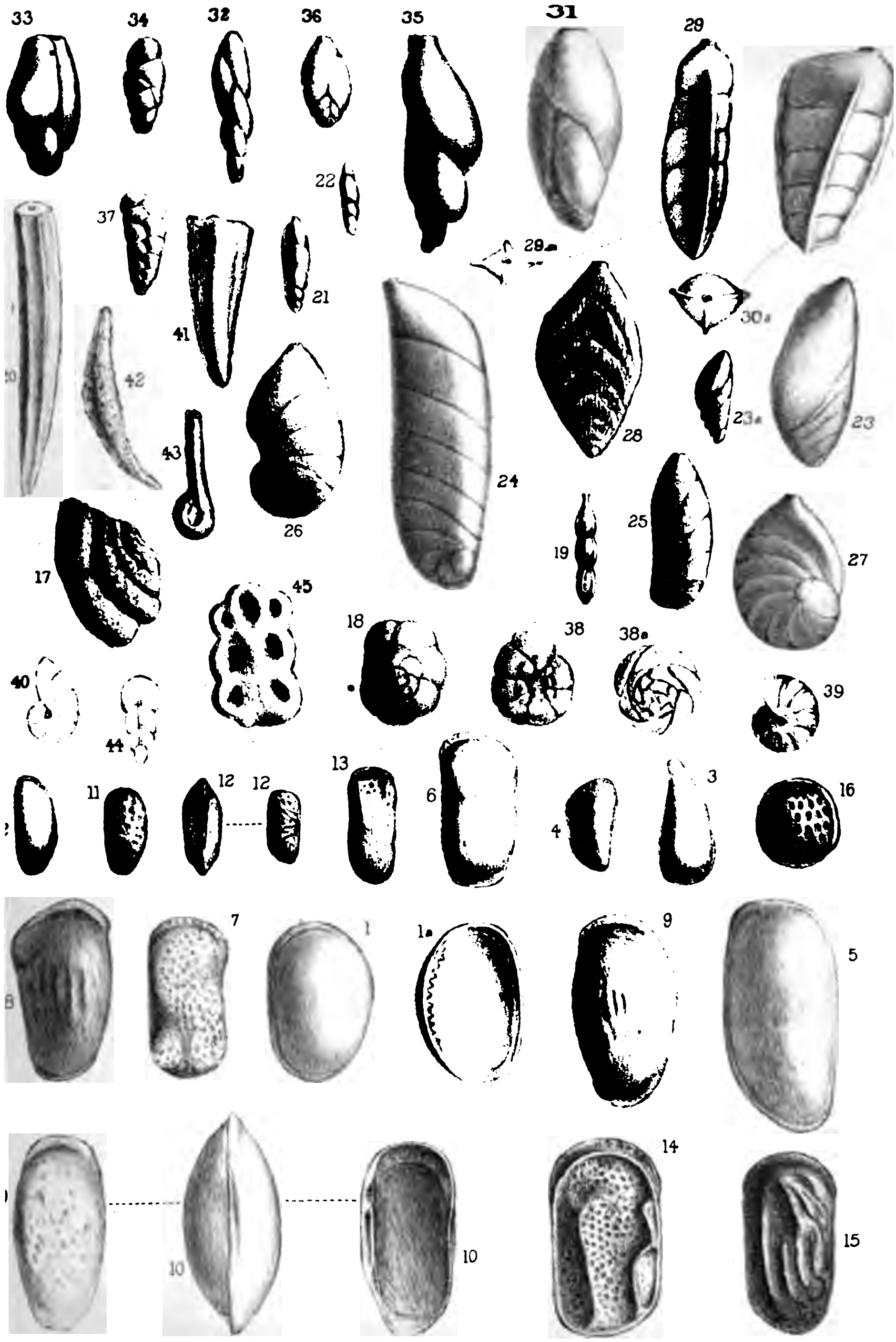
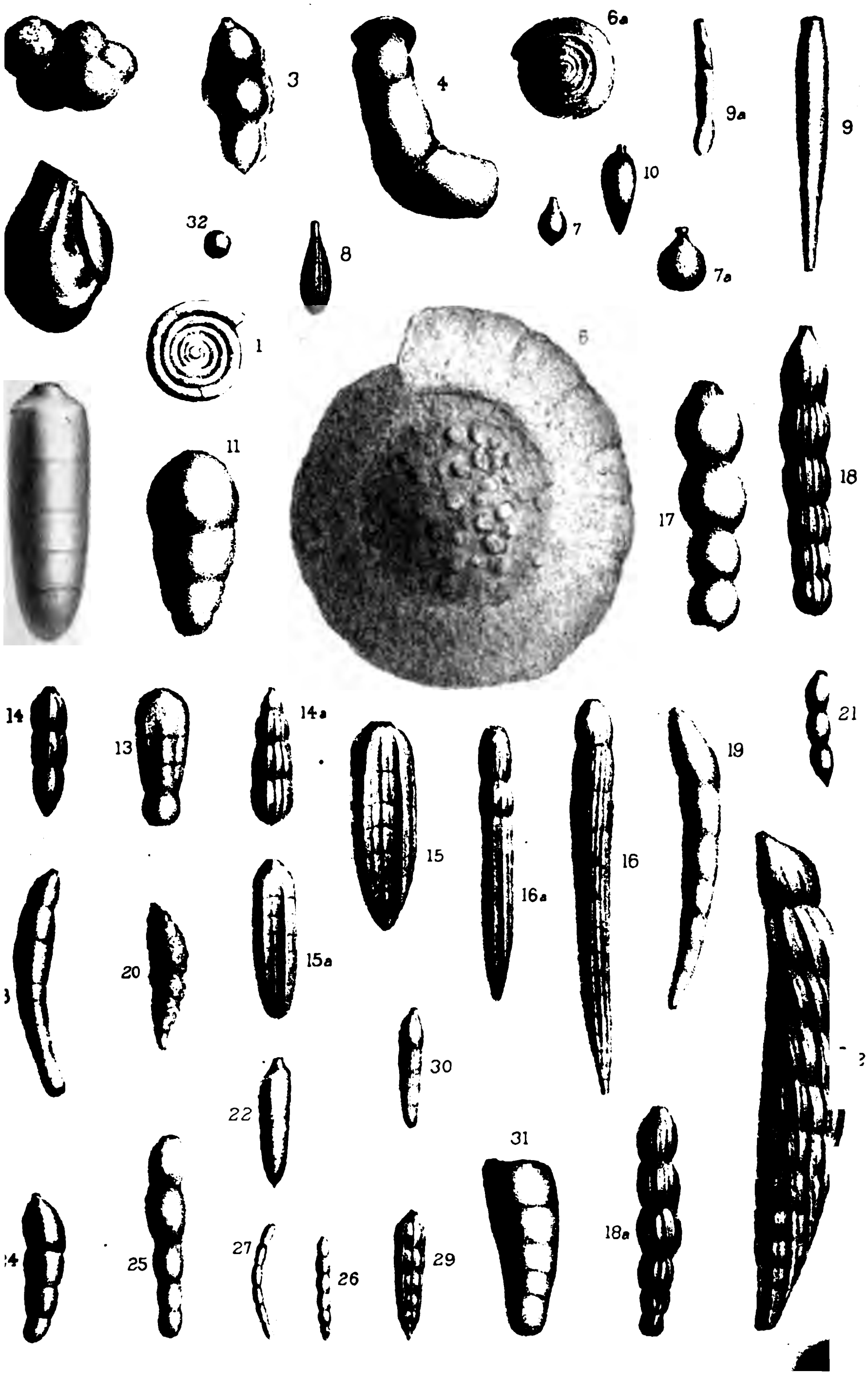
PLATE XVII.



Hanhart imp

PLATE XVIII.



Geo. West lith.

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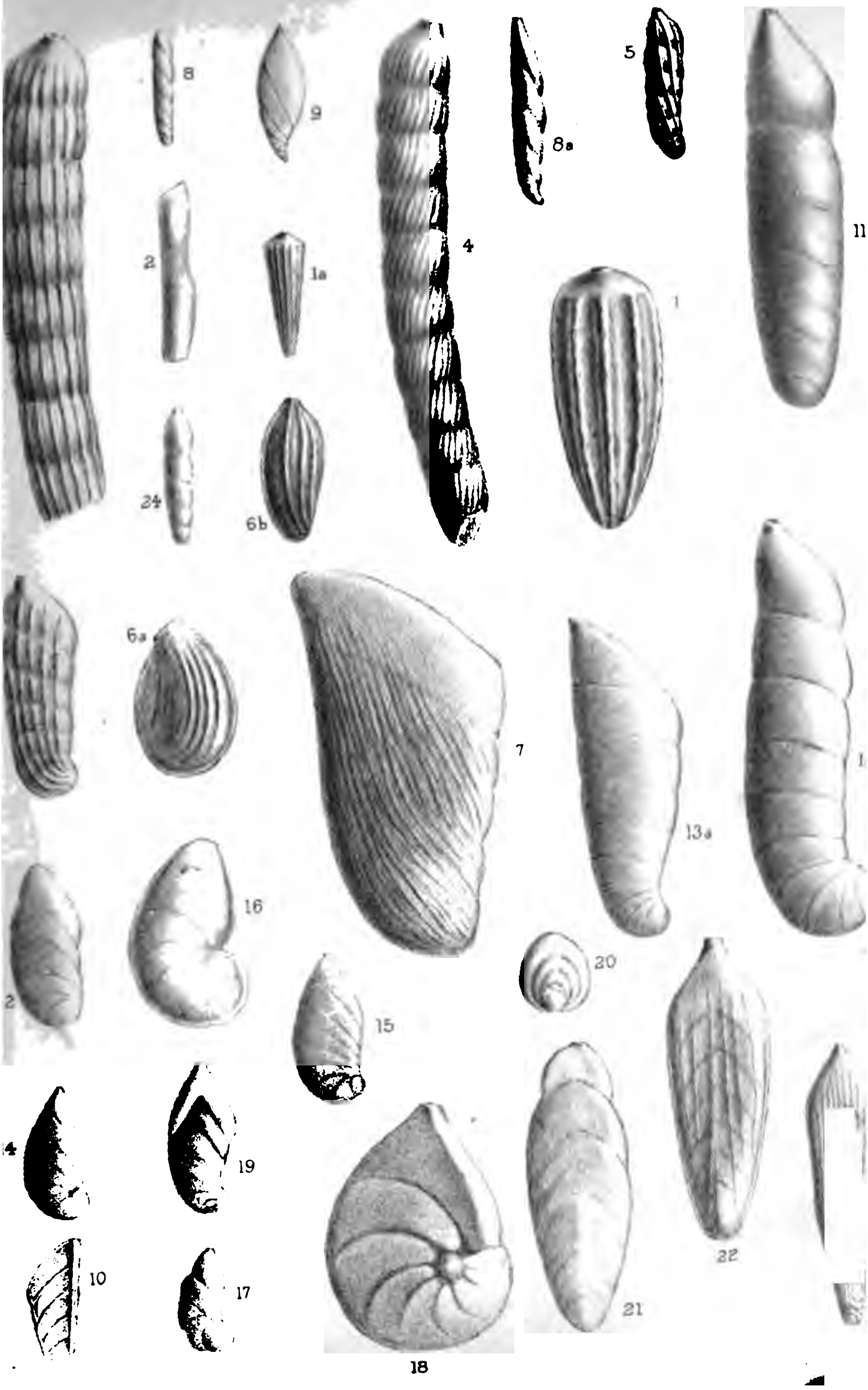
PLATE XIX.



Geo. West lith

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